JOURNAL
OF
ECONOMIC ENTOMOLOGY
OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

VOL. 8 APRIL, 1915 No. 2

Proceedings of the Twenty-seventh Annual Meeting of the American Association of Economic Entomologists

(Continued)

Afternoon session, Tuesday, December 29, 1914, 2.00 p. m.

PRESIDENT H. T. FERNALD: We will now listen to a paper by W. W. Yothers.

SPRAYING SCHEME FOR THE CONTROL OF INSECT PESTS ON CITRUS TREES IN FLORIDA

By W. W. YOTHERS, *Bureau of Entomology, Orlando, Florida*

Of the total damage caused by insects to citrus in Florida more than 95 per cent may be attributed to six species. The most destructive is the citrus white fly (*Aleyrodes citri* R. & H.) which now infests nearly all the groves in the state. The second most destructive pest is the purple scale (*Lepidosaphes beckii* Newm.) which is found in greater or less numbers on every citrus tree in the state. According to my observations the rust mite (*Eriophyes oleivorus* Ashm.) ranks third. The Florida red scale (*Chrysomphalus aonidum* L.), the cloudy-winged white fly (*Aleyrodes nubifera* Berger) and the red spider (*Tetranychus sexmaculatus* Riley) are also of primary importance. It has been the object for several years to perfect a spraying scheme which would largely eliminate the damage caused by these pests. There are also several pests of secondary importance such as the woolly white fly (*Aleyrodes howardi* Q.) and the purple mite (*Tetranychus mytilaspidis* Riley), which this spraying scheme will also partially or completely control.

As a general proposition the time to spray for the control of all pests on citrus trees is when they are present in such numbers that,

if left to reproduce without artificial hindrance they would soon become injurious. In other words, the pests should be killed before they do much damage to either the tree or fruit. The pests should always be kept in such a state of subjection as to do little or no damage. In case the various pests to citrus trees are permitted to become so abundant as to cause damage, the profits which might be derived from artificial treatment, such as spraying with an insecticide, are, to a certain extent, lost. The life history and habits of nearly all pests on citrus trees are, fortunately, such that good and satisfactory results can be obtained any time the spray is applied. While such is the case there are times when it is opportune to spray. These periods come when the largest percentage of the insects is in the youngest stage, which is the one most easily killed.

The following spraying scheme has been used quite extensively for three summers and has generally given satisfactory results. It must be admitted, however, that no hard and fast scheme can be given, and the number of sprayings depends to a large extent on the thoroughness of the work.

I. Paraffin-Oil Emulsions; Government formula 1-50 or 1 per cent of oil—May. The main object of spraying at this time is to kill the white fly, scale insects, and to a large extent rust mites, although this treatment must not be relied upon to control the last. This spraying should be given after the adults of the first brood of white flies have disappeared and before the appearance of those of the second brood. The fruit should be an inch or more in diameter when the spraying is done. This treatment should be given before the beginning of the rainy season, so that the beneficial fungi will take care of those insects which are not killed by the spray.

II. Lime-Sulphur Solution, 32° Baumé, 1-50 to 1-75—June to July. The main object of this treatment is to kill rust mites and the opportune time for its application varies with the appearance of the maximum number of the rust mites. It should be applied before the mites get very abundant and before any russeting appears. It will also kill some scales and white flies, but is of little value for that purpose.

III. Paraffin-Oil Emulsions; Government formula 1-50 or 1 per cent of oil—August 25 to October 31. This is the second spraying for the white fly and scale insects. The object of spraying at this time is to kill all the white fly larvæ which are the progeny of the third and last brood. It is this brood which causes nearly all the damage from the white flies, and the earlier they are killed the better it is for the tree. This spraying also comes after all the beneficial fungi have done their work. This will also remove the sooty mold from the trees and

sufficiently from the fruit to permit the sun to color it up. Soda-sulphur 1-50 may be added to this spraying and this will increase its effectiveness in killing rust mites.

IV. LIME-SULPHUR SOLUTION, 32° Baumé, 1-50 to 1-75—November or December. The object of this spraying is to kill rust mites and it may or may not be necessary, depending on the abundance of the mites.

It may be necessary to spray for rust mites before No. 1 is given. In case the red spider becomes abundant enough to be injurious, a spraying with lime-sulphur solution should be given. It may also be necessary to spray three times with the oil sprays, in which case this treatment can be given in midsummer or in winter. If the red scale is very abundant, two sprayings with the oil emulsions should be given at intervals of about a month.

The paraffin-oil emulsion may be made according to directions given in Circular No. 168, Bureau of Entomology. In addition to the above there are two miscible oils on the market in Florida which are highly satisfactory. The soda-sulphur solution is made according to the standard formula, 30 pounds sulphur, 20 pounds caustic soda, 20 gallons of water. This tests about 16° Baumé and may be used 1-40 instead of lime-sulphur solution but it is not so effective in controlling rust mites. It has the advantage of the lime-sulphur solution in that it will mix with the oil emulsions. To follow the above scheme it will cost from 20 cents to 35 cents a year per tree. It costs one grower 20 cents for trees of about five-box capacity or 4 cents per box. Another did the work for 32 cents for eight-box trees or 4 cents per box. It cost several other growers 3, 3, 6, 7, and 8 cents per box respectively. A maximum figure would be 8 cents per box.

Even though this scheme is not strictly adhered to it will result in raising the grade of the fruit. The second grade will become first, the third will be largely eliminated, and the culls will almost disappear. The increase of production due to the increase in size of the fruit resulting from the elimination of the rust mite will be from 12½ to 25 per cent, amounting approximately to two million boxes. The devitalizing of the trees by the insects would be eliminated and the trees would then expend their vitality to produce fruit instead of nourishing insects. This would also increase the quantity and quality of the fruit and make a crop more certain from year to year, which would be crop insurance. It is a conservative estimate that the total benefits which would be derived, if this scheme was followed throughout the state, would be not far from an increase of production of a minimum of 25 per cent over that which is the result at the present time with a total de-

pendence on the beneficial parasitic fungi. The appearance of the fruit on the market would be vastly improved. The total dependence of the Florida citrus grower on natural enemies for the control of the pests on citrus trees is a delusion.

February 2, 1915.

PRESIDENT H. T. FERNALD: The next paper on the program will be read by P. J. Parrott.

AN ANALYSIS OF SPRAYING METHODS AGAINST THE CODLING MOTH

By P. J. PARROTT

One who has at heart the permanent prosperity, extension and normal development of fruit-growing in New York can hardly fail to be impressed with two facts: (1) The increased planting of apple trees, so that the care of orchards frequently over-shadows all other farm operations, resulting in an unbalanced state of farming; and (2) the growing necessity of more frequent and thorough applications of spraying mixtures. In addition to scab, scale and codling moth, it is now the lot of many orchardists to have to contend against fruit-puncturing capsids and leaf and fruit-infesting aphides; and spraying for these has become a regular part of the routine prescribed by the latest and most approved spraying schedule. The cost for spray materials is also increasing. Formerly lime-sulphur and arsenate of lead sufficed for the principal ills that the apple is heir to, but now the grower must needs use lime-sulphur and lead, plus other substances; and according to present usage nicotine is the most popular third constituent in the combination of spraying materials.

Individually and collectively the growers of New York are confronted with what may prove to be a great economic problem. In addition to the necessity of maintaining a high state of culture at increasing expense, they are apparently facing a period of diminishing returns. As a result more serious thought than ever before is being given to a study of methods of producing maximum yields of high-grade fruit at minimum cost. A partial solution of the dilemma is to improve spraying practices, at least as to the character, if not number, of the treatments. In spite of present methods, injurious insects are responsible for great reductions in financial returns. Moreover, in addition to direct losses, failure to maintain a high level of spraying practices may have the effect of neutralizing, if not actually destroying any benefit by other standard operations, as pruning, thinning, cultivation, etc., so essential today for the upkeep and

profitable production of the orchard. The objection to such a proposition by the average orchardist at first thought is, I fancy, that of cost; it being urged that most growers are already putting more into this operation than can be afforded, and one which, in addition to other objectionable features, calls for a cash outlay. A study of orchards under Station control suggests that the problem is in reality not so much a matter of cost as a matter of time,—to find time to spray the trees thoroughly at each critical period, and yet not neglect other orchard operations or other crops when they too demand proper attention.

As to expensiveness of spraying, the Auchter[1] orchard, now in its fourth decade, has yielded the Station during the past decennium a net profit per year of $120.60 per acre. On the cost sheet for a barrel of apples are nine items of expense amounting to $1.29, which covers the growing, harvesting and delivery of the fruit to the railroad station. In order of importance as regards extent, spraying ranks as fifth in the list, and amounts to only 7½ per cent of the whole cost involved in producing a barrel of apples for the market. This sum is not large, and considered in the light of losses sustained, it appears that more money could well be expended for spraying operations. Under present conditions this would necessitate more spraying rigs and additional crews of men, with the attendant difficulty of finding profitable employment for both horses and men when their presence was not needed in the orchard. These considerations suggested the wisdom of purchasing and testing out a high-pressure outfit as one possible means of developing economy and raising the efficiency of spraying practices in New York. It was thought that with an outfit of large capacity and power not only could more acres of orchard be sprayed within a given time, but that with a great volume of spray under high pressure, more effective work could be done against such pests as fruit-puncturing capsids, pear thrips, apple aphides and perhaps the codling moth.

Because of unfamiliarity as regards the essentials for such an outfit we sought the advice of Dr. A. L. Melander and, in accordance with his specifications, we purchased a spraying machine which is capable of maintaining a pressure of 300 pounds or more and discharging a flow of spraying mixture as high as fifteen gallons per minute, with a set of four "Clipper" nozzles. The hose was in two lengths of fifty feet, furnished with extra long couplings and equipped with eight-foot brass-cored extension-rods. The outfit, when carrying a load of two hundred gallons of spray, had a weight of about 3600 to 3800 pounds, which is less than that of some machines we have used in the past.

[1] Geneva Bulletin 376, 1914.

Of the various experimental activities conducted also under the immediate supervision of one entirely familiar with the western methods of high-pressure spraying, two projects are at this time of special interest: (1) Penetration of spraying mixtures to lower calyx cavity of apples by high and low pressures, using respectively Bordeaux and Vermorel nozzles, and (2) Comparative effectiveness of high and low pressures with the foregoing two types of nozzles against the codling moth.

Penetration of Lower Calyx Cavity

In the experiments against the codling moth it was obvious at the outset, that notwithstanding what system was being followed, only a very small percentage of the young apples showed penetration to the lower calyx cavity by the liquid. In order to get further data on this point it was decided to stain the spraying mixture, which was accomplished by using ten packages of "Diamond Dye, Crimson" to about ten or fifteen gallons of the liquid. The dye was added during the course of the regular spraying operations, as demanded by the tests in a Baldwin orchard, but as soon as the colored spray was being discharged at the nozzles the operators were urged to take special pains to do thorough work, shooting as it were the spraying mixture into the throat of every blossom. Immediate examinations substantiated previous observations, but in order that closer inspections could be made, whole clusters of apples were removed from the trees and examined in the laboratory under a lens, where the condition of each fruit with respect to the penetration of the liquid was noted. The data, as finally classified, is contained in the following table:

Table I. Showing Penetration by Bordeaux and Vermorel Nozzles

Conditions of Calyx Cavity	Vermorel Nozzles		Bordeaux Nozzles	
	No.	Per cent	No.	Per cent
Apples examined	135		62	
Apples with spray in lower cavity	0		0	
Apples stained at point of contact of stamens	9	6.6	5	8.1
Apples with traces of stained pollen in lower cavity	32	23.7	12	19.4
Apples with considerable stained pollen in lower cavity	21	15.6	13	21.0
Apples with no stained pollen in lower cavity	82	60.7	37	59.7

Comparative Effectiveness of High and Low Pressure Spraying Against the Codling Moth

In view of the foregoing figures it is now of interest to note the results of spraying in this orchard with respect to the protection of the crop by the two methods of spraying. Arsenate of lead was

used in amounts varying from one to three pounds to fifty gallons of water. The strength of lime-sulphur was one gallon of concentrate testing 32–34° B. to forty gallons of water. Applications were made with pressures of 300 pounds or more with Bordeaux nozzles and about 200 pounds with Vermorel nozzles.

TABLE II. SHOWING RESULTS FROM HIGH AND LOW PRESSURE SPRAYING

Conditions	Sound Apples	End Wormy		Side Wormy		Total No. of Apples	Per cent Wormy
		No.	Per cent	No.	Per cent		
Vermorel 3 lbs. to 50	7603	60	0.72	645	7.76	8308	8.48
Vermorel 3 lbs. to 50	6192	45	0.67	515	7.63	6752	8.30
Bordeaux 3 lbs. to 50	7532	22	0.28	406	5.10	7960	5.38
Bordeaux 3 lbs. to 50	3376	6	0.17	229	6.34	3611	6.51
Bordeaux 1 lb. to 50	6427	71	1.02	439	6.33	6937	7.35
Bordeaux 1 lb. to 50	5079	40	0.73	340	6.23	5459	6.96
Vermorel 1 lb. to 50	5417	53	0.89	464	7.82	5934	8.71
Vermorel 1 lb. to 50	5286	111	1.92	384	6.64	5781	8.56
Bordeaux 2 lbs. to 50	7361	20	0.26	330	4.28	7711	4.54
Bordeaux 2 lbs. to 50	7710	53	0.66	307	3.80	8070	4.46
Vermorel L. S. & Lead 1-50	5880	103	1.56	601	9.13	6584	10.69
Bordeaux L. S. & Lead 1-50	8331	123	1.34	693	7.58	9147	8.92
Check	5968	318	4.45	866	12.11	7152	16.56
Check	5280	234	3.56	1055	16.06	6569	19.62

The data as presented are based only on preliminary experiments which were conducted during the past season under the efficient direction of a western expert in order to familiarize our entomological staff with the methods of high-pressure spraying; and there is no necessity for anticipating conclusions. However, it is apparent that the results, while of interest to professional workers, have a practical bearing. To follow the advice that "the spray be directed from above and be driven squarely against each blossom" in a typical apple orchard in western New York composed of trees that are high and of great expansion, would raise a lot of new problems, involving largely the surmounting of practical difficulties that would not prove easy to conquer; in fact, if the season's experience is a criterion, would stir up more hares than one would care to run down. On the other hand, if penetration of the lower calyx cavity is not really necessary under our conditions, then the needs of the orchardist can be met with a broad sweeping spray. From this standpoint a high-pressure outfit would still possess merits—rapidity of discharge and carrying power of the spray, affording possibilities for economy of time and a wide field for the development of higher standards of spraying than now generally prevail.

MR. C. T. BRUES: I am very much interested in this paper, for, as you know, somewhat similar work with high-pressure spraying has been done in the West by various entomologists. I must admit I am not quite familiar with the percentages of sound fruit which are generally obtained in the most successful work in the West. If Mr. Parrott can tell us what the percentages are I would like to know.

MR. P. J. PARROTT: By means of high-pressure spraying they have been able to grow apples in the West that run 95 to 97 per cent free from injury by codling moth. On the other hand, it is reported that by the use of Vermorel nozzles great losses to the crops are sustained. Evidently eastern and western entomologists, as far as control of the codling moth is concerned, are working under different conditions.

MR. C. T. BRUES: Dr. Melander is also of this opinion. I saw him for a few hours after his return from the experiments in New York, and I judged from what he said that the sprays failed to penetrate, at least to the extent that normally occurs in the West. Is it not possible that there is difference in the position of the floral parts?

MR. P. J. PARROTT: I believe that is the pith of the matter.

MR. E. P. FELT: I would like to ask at what time in the development of the blossom was the spraying done—after the stamens were dry or were they still green?

Mr. P. J. PARROTT: The petals had dropped and the stamens were commencing to shrivel.

MR. E. G. TITUS: How near did you get to the blossoms and did you actually drive the spray in?

MR. P. J. PARROTT: In the case of the apples, which were examined to determine the extent of the penetration of the colored spray, the nozzles were held quite close to the fruit-during spraying operations. These showed no penetration, but it should be stated that in the course of the various experiments the spraying mixture was sometimes found in the lower calyx cavity. Certain it is that, under the conditions in which we were working, it was not an easy thing to force the spray through the different structures in the calyx cup of the Baldwin apple.

MR. A. L. QUAINTANCE: For the last two or three years the Bureau has been making a comparative study of the calyx cup in eastern and western apples and it shows that the western apple has a much more open arrangement of the stamen bars than the eastern apples, and this explains the situation. The position of the western entomologist and the position of the eastern entomologist are accounted for by the difference in the arrangement of the stamens.

MR. P. J. PARROTT: In the October number of the *American Naturalist* there is an article by Mr. W. J. Young which clearly explains

the variations in apples due to differences in environment. I hope later to add more to this phase of the question.

MR. W. M. SCOTT: There is another question that Mr. Parrott's paper raises and that is the question of pressure. I think that we have been somewhat extreme on that point. The spray pump people have vied with each other to put out machines that would give the highest pressure and deliver a large quantity of material per minute. The result has been, according to my observation, injury to fruit and foliage by an excess of spraying material in the first place, and in the second place (and I think not an unimportant point either) by actual mechanical injury from driving spray under high pressure.

I have been knocking around over the country quite extensively in the last couple of years, looking into just such matters, and I frequently find apple crops injured by arsenate of lead and lime-sulphur solution. Upon making inquiry I find that most of that injury is found in orchards where high-pressure machines have been used. Professor Quaintance and I, a few years ago, conducted a coöperative experiment in the use of lime-sulphur solution and arsenate of lead in spraying apples under high pressure. I think we had 300, possibly 350, pounds pressure and on the trees that we sprayed under that pressure, the foliage was badly injured and the fruit badly burned—to the extent perhaps of 50 per cent loss of the crop. Whereas the adjacent trees sprayed with the ordinary outfit, using the mist type of nozzle, did not show the injury—or at least not very much of it.

I think that is a point we ought to bear in mind in recommending applications with high pressure machines.

MR. E. G. TITUS: In Utah it appears that 125 pounds is sufficient so far as pressure is concerned. The ordinary barrel pump will give sufficient pressure with the ordinary driving spray and will give better results than a 300-pound pressure outfit. It has been done many times. So far as penetration is concerned, we can penetrate with this pressure in a very high percentage of cases. In some recent experiments against the fruit-tree leaf roller, in which the question of the codling moth came in, I had no trouble at all with an ordinary barrel pump in getting less than one-tenth of one per cent calyx wormy, and less than five per cent side worms in the orchard, and I am certain that we did not get a hundred-pounds pressure. On another orchard we used a power pump, but didn't attempt to get over 150 pounds at any time—I do not think it is necessary. The very high pressures not only injure the apples, but they actually blow some blossoms right off the limbs.

MR. WATKINS: Perhaps you would like to know the policy of the University of Illinois. For five years we have been recommending

pressure at 125 pounds and nothing higher. This past year we have estimated that we had 1800 per cent moth, that is, 18 worms for every unsprayed apple.

In our 1914 pressure experiments similar to Mr. Parrott's, we found that a pressure of 125 pounds controlled the moth more efficiently than 250 pounds. We also found that nozzles which produced a mist spray were preferable to the Bordeaux nozzle.

Hence I believe in using and continuing to use things which we know to be effective in our own orchard. The trouble I find in our experiment station work is that growers are in the habit of taking up with any new hobby that comes along. Because Professor Melander in the State of Washington is successful in controlling the codling moth by using high pressure, it is no sign that we can have equal success with the same methods here. We can probably get good results regardless of the number of poisoned particles which lodge in the calyx cup.

MR. A. L. QUAINTANCE: I take the liberty to speak again to endorse the remarks made in regard to pump pressure in spraying. A good deal of evidence is accumulating which indicates that very thorough work may be done in the control of the codling moth by a much lower pressure than is currently believed. I would not be surprised that we shall find that from 125 to 150 pounds pressure, with good thorough spraying, will answer, as well as 200 or 250 pounds pressure. Coarse nozzles, of the Bordeaux type, at least under eastern conditions, do not seem to give superior results in the protection of fruit than Vermorel or Eddy Chamber nozzles, and the latter, as is well known, are much more economical of the spray liquid.

MR. E. N. CORY: Have you had any experience with the airtight sprayers run at 175 pounds pressure on the principle of the atomizer?

MR. WATKINS: The airtight sprayers have changed this year so that it is impossible to justify any recommendations. Last year they were run by a two-cycle engine and no agitator; this year they have a four-cycle engine and an agitator. The University of Illinois spraying specialist is pretty strong for an agitator, and we did not get one there last year for the simple reason that it did not have an agitator. This year, since it is made with an agitator and the four-cycle engine, it is our intention to test it. I know of several machines that were turned back to the company last year.

PRESIDENT H. T. FERNALD: The next paper on the program will be given by Mr. Shelford.

SUGGESTIONS AS TO THE ORIGINAL HABITAT AND DISTRIBUTION OF VARIOUS NATIVE INSECT PESTS

By V. E. Shelford, *University of Illinois*

I. Introduction.—Before Eastern North America was put under agricultural conditions it was densely covered with forest west to the Illinois and Mississippi Rivers, and with conifers to the north, Fig. 10. Along the western border of the forest was a belt of prairie or savanna which consisted of groves of forest, stream skirting forest, interspersed with moist grassland. To the west of this were the arid plains along the rivers of which was moist area vegetation. Considering the forested portion of this we cannot too much emphasize the fact that it was continuous forest entirely different from the present open aspect. The forest was broken in the eastern portion by rivers and marshes and sand dunes of the lakes and coast, which formed an insignificant portion of the entire area. In addition to this there were small "islands" of moist prairie scattered eastward north of the Ohio River as far as central Ohio.

Scarcely any of the pests of forage or garden crops are forest animals, and only a few orchard and small fruit pests are strictly so. When we consider that these pests have made their way in Eastern North America at least, on to planted crops where ever and as fast as these have been put out, we must explain their presence either by assuming a rapid migration with the development of agriculture and the clearing of the land, or we must assume that these animals were present through-out the forest area before agriculture was introduced. While some species have migrated beyond doubt, others have in all probability notd one so.

II. The Original Habitat of Native Pests.—A close study of the habitat preference of various insects appears to throw much light upon the original habitat of a great many native pests. Taking first the insects which frequent garden and forage crops and which are widely distributed, an inquiry into their habitat shows that they fall into two classes, (*a*) those frequenting low moist situations, and (*b*) those preferring higher and drier ground. An examination of the fragments of primeval vegetation likely to support such insects shows that the moister situation frequenting species are found along the margins of ponds, (Pl. 7, fig. 1), lakes, rivers and even on the vegetation growing in the water, and on marsh meadows or grassy areas covered by water in spring but dry in summer.

Taking Sanderson's recent work on insect pests and Forbes' report on the insects of the Indian corn plant and comparing them with lists

Figure 10—Showing the distribution of vegetation in North America before it was put under agricultural conditions. The shaded "prairie" area may be regarded as the original center of abundance of agricultural pest species.

of species taken by the writer on the margins of ponds and lakes such as are shown in Plate 7, figure 1, we find that one third of the phytophaga listed are mentioned by one or both of these authors. A comparison of lists of species taken from the margins of sandy depressions such as occur about the lakes and larger rivers and we find again roughly one-third of the species mentioned by one or both of these authors.

In the forest area lakes and ponds formed by glaciation and the "oxbows" by rivers often filled with vegetable detritus and become covered over with a low wet meadow, a part of which may be under water in spring. Such situations were originally common throughout the eastern portion of the United States, particularly where glaciation has taken place, but are by no means wanting in other localities. These moist meadows nearly always were surrounded by forest and the boundaries between them were forest edges. A forest edge is a thicket made up of rank weeds on the side nearest the meadow; inside of these are various shrubs arranged in belts and increasing in height as we go toward the forest. Considering the marsh meadows and associated forest edges we find on comparing lists of species collected from these situations with the works mentioned above, that more than one-half of the phytophagus species are mentioned as important.

Turning to the species which frequent the higher and drier ground and which are found under the same conditions as crop pests, we find that the steep lake (Pl. 7, fig. 2) and river bluffs, the bare rocks exposures upon which trees do not grow, support numbers of them. The bare steep bluffs are the haunts of the dry bare ground frequenting forms like *Dissosteira carolina* and the vegetation supports aphids, locustids, and beetles of great economic importance.

The forest encroaches upon these situations as a shrub thicket similar to the moist forest edge. These shrubby thickets are made up of hawthorn, wild plum, with occasional cherry, gooseberry, cottonwood, willow, etc. These are the headquarters of the pests of small fruits, apples, etc., and preëminently the headquarters of the orchard birds. These shrubby thickets of the river banks, etc., are duplicated on the flood plain itself where hawthorn, grape, currant grow either in open scattered formation or in dense thickets. These thickets support the majority of our native pests of the fruit-bearing trees and shrubs.

III. The Original Distribution of Native Pests.—Considering the distribution of the marsh and moist vegetation inhabiting species, we find that on the whole it is exceptionally wide, and similar to the distribution of the marshes themselves, and within wide range of climatic conditions represented by the greater part of the United States and Southern Canada (except the arid southwest) and a northward extension in the plains and prairie region of western Canada (Fig. 10). Some of the species common in the swamps of New England may be found on the prairies at Edmonton and the grassy marshes of the lower Mississippi and along the irrigation ditches of the Rio Grande in New Mexico.

The species occupying the higher drier bare ground, and scattered

vegetation growing upon it were not distributed essentially differently from the above, but were near to water in the more arid climates.

The native pests of our fruit-bearing shrubs and trees were originally less widely distributed than the others because the thickets which supported them were less widely distributed, being confined more generally to the deciduous forest area (Fig. 10) and the savanna or moist prairie area.

IV. CENTER OF ABUNDANCE OF NATIVE PEST SPECIES.—We cannot too strongly emphasize the unbroken character of the original forest of the area shown as forested in the map (Fig. 10). Accordingly the pest species referred to above were crowded into the cracks of the forest and scattered along the river margins of the great plains. The area shown as prairie in figure 10 is made up of moist grass land, river skirting forest with groves away from the rivers making the forest edge or thicket of hawthorn and plum a very important habitat in this region. With the extensive moist grass land areas mixed with this, the space available for pest species was great. We may consider the original center of distribution and abundance of native pests as lying within the area of "prairie" or savanna shown in figure 10.

V. THE EXPANSION OF LOCAL RANGE OF PEST SPECIES UNDER AGRICULTURAL CONDITIONS.—With the clearing of the land and the putting out of crops in the forest area, the habitats of the pests in the cracks and corners in the forest was expanded to cover the agricultural lands as far as they were cleared. With the building of roads the roadside ditch, roadside thicket and the road itself made a complex supporting all of the various types we have mentioned (Fig. 3). Thus the local species of primeval conditions took on a general distribution under agricultural conditions.

EXPLANATION OF PLATE 7

1. A pond margin; a type of situation of very wide distribution in North America—one-third of the phytophagus insects taken here are mentioned by Forbes and Sanderson.

2. Dry clay bluff supporting such forms as *Dissosteira carolina* and the vegetation of which supports the Xiphidiums, aphids, and plant bugs common on crops grown on high dry ground.

3. A roadside habitat combining most of those mentioned in the paper as normal to primeval conditions.

PRESIDENT H. T. FERNALD: The next paper on the program will be by Mr. E. G. Titus. He will speak on "A Clean Town Contest."

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A CLEAN TOWN CONTEST

By E. G. Titus, *Logan, Utah*

This movement has been carried on to some extent in other states and has been supported by mayors, officials, boards of health, and so on, but we intended it to be a state contest. A year ago we started work upon this Utah contest and on the first of June, 1914, we had fifty-six towns entering the contest. These were divided according to population, Salt Lake and Ogden being of course the largest. In the next class, 3,500 to 9,000 towns, three out of the four in the state entered. The next class 2,500 to 3,500, seven towns entered out of eleven in the state; in the next class, 1,500 to 2,500, ten towns out of sixteen entered; Class "E," 750 to 1,500, eleven out of twenty-eight entered; and in Class "F," towns under 750, there were fifteen out of thirty-eight that could have entered the contest. We had a fairly representative number of towns in the state entered. A number of prizes were offered by the Utah Development League. In a number of towns that went through the competition there were also side prizes for better lawns, best appearing lots, best flower gardens, best equipped places in the business section of the town, etc.

The following are the final scores of the towns entered and scored:

Class "A": Cities of 25,000 and over.

Ogden	73
Salt Lake	70

Class "B": Towns of 3,500 to 9,000 population.

Brigham	70.6
Provo	64.6
Murray	46.5

Class "C": Towns of 2,500 to 3,500 population.

Lehi	71.7
Spanish Fork	62.5
Springville	61.8
Richfield	59
Park City	59
American Fork	55.5
Nephi	41

Class "D": Towns of 1,500 to 2,500 population.

Manti	82.5
St. George	70.5
Beaver	70
Smithfield	69.3
Cedar City	65.0
Richmond	52
Pleasant Grove	51
Ephraim	43
Bountiful	40
Payson	35.1

CLASS "E": Towns of 750 to 1,500 population.

Farmington	67.5
Fairview	67
Parowan	62
Kaysville	59
Panguitch	57
Sandy	54.4
Coalville	52
Fillmore	50
Providence	48.3
Salina	43
Morgan	42

CLASS "F": Towns under 750 population.

Hurricane	78
Mapleton	66.8
Millville	56.1
Levan	54
Salem	54.6
Mayfield	52
West Bountiful	52
Minersville	52
Washington	48
Randolph	48
Tremonton	45.3
Scipio	45
Alpine	50.5
Garland	29.3
Kamas	39

The following notice gives the system of scoring:

INSPECTION

Inspection of the towns will begin August 17th and continue until all entering the contest have been inspected and scored. No information will be given as to date when inspection will be made. All towns must be ready for inspection.

TOWNS WILL BE SCORED ON THE FOLLOWING POINTS

Basis 100

	Points
1—Sewage: Disposal of—privies, cesspools, etc.	15
2—Stables and corrals, disposal of manure, etc.	15
3—Garbage, collection and disposal	10
4—Water supply	10
5—Sanitation of school houses and other public buildings	5
6—Sanitary marketing of foods	5
7—Presence of flies	5
8—Sanitation of the home, cleanliness of the home, ventilation, etc.	5
9—Condition of streets, parks and alleys	10
10—General appearance of homes, barns, barnyards	5
11—Lawns and flower gardens	5
12—Vacant lots	5
13—Fences	5
Total	100

The State Board of Health had charge of the inspection of the towns and the whole competition was carried out in a most friendly spirit. Its developments were remarkable, if only purely in advertising for the state, and this is incidentally one good means of advertising.

MR. C. GORDON HEWITT: We are all aware of the great importance of movements of this kind, and I believe every one of the members here has listened with much pleasure to Professor Titus' account. One of the things that has particularly impressed me, as shown by that small diagram of a section of a town, is the enormous amount of work which has been involved in making a survey of this kind. If Professor Titus' paper has shown us nothing else, it has demonstrated that the entomologist is something more than a man who goes around recommending "how to squirt trees"—but a man who is becoming more and more intimately concerned with the life of the people. We heard last year in our meeting at Atlanta a paper by Professor Hinds in connection with boll weevil work in the south, how the entomologist was becoming more and more concerned with the life of the people and with their economic conditions which are not entirely "entomological." I think this paper by Professor Titus shows the entomologist to be something more than a person who simply destroys insects, and that he is becoming more and more vitally concerned with economic studies and with the movement for improved conditions of life for people generally.

MR. R. A. COOLEY: I would like to ask the amount of expense involved in conducting this campaign?

MR. E. G. TITUS: From the standpoint of the town I am unable to state, not having the figures. We are attempting to gather them and hope to have them tabulated some time this winter. In case of the Utah Development League, the chief expense possibly was the clerical help and the printing of circular letters of the type I have sent around for examination; for a circular of this kind (indicating), another one of this kind (indicating), and all showing the *Clean Town* policy and scheme. And the money expense was defrayed from the expenses of the Utah Development League as part of the advertising campaign. The largest expense was judging the towns. I have not the judges' expense accounts, but I can figure on judging thirteen of the towns, in classes "B" and "C," and I think the judging occupied from two to four days to a town. In class "C," most of the towns could be judged in from one and a half to two days, and in class "B" three days. It would not average over twenty-five dollars a town except for class "A." Of course for the larger towns it cost more and in the smaller town it

dropped down perhaps to four or five dollars. Then there were some more inaccessible. For instance, there was one town one hundred and fifty miles from a railroad, took two days on a stage, and then a day and a half to get to the town with a rig after that, away back in the mountains. There were several towns located in this way and the judging expense of course was high. Some of the towns offered to defray part of the expense in order to be sure that the judge came down and visited them. Perhaps the little town of Manti cost the most to the town since the town offered a large number of prizes and they went into it rather heavily. The interest was so strong that when the judging was postponed for several days, they received word by telephone, and they had a man out in an automobile the next morning with a megaphone announcing that they had "three more days to clean up" and "to get busy." And they did get busy.

So far as the expense is concerned, it is really small, I believe, compared with the benefit the town received from it. Even real estate men were interested and some told me that the increase in the value of real estate was worth many times the cost it had been to the town or state.

A MEMBER: The expense then was borne by the Development League?

MR. E. G. TITUS: Yes, and also the State Board of Health, and others, and then we brought in one man from outside to judge Salt Lake and Ogden. There was considerable rivalry between the two cities—they are close together.

A MEMBER: I want to express my appreciation and hearty approval of this line of work. I know something about such work and judge that it must have taken an enormous amount of energy and labor to carry this contest to a conclusion.

MR. E. G. TITUS: Larvacides were used to a very slight extent; the main thing was to get manure out of the way. In some of the towns we did try out borax and other things. We had some manure containers or large vats built in the state; we built one at the college and I believe there have recently been others built at different times. They suit us pretty well.

MR. F. C. BISHOPP: I am sure Dr. Titus is to be congratulated on the admirable way in which this campaign was conducted. I was much pleased with the results secured in the small towns. From the little we have been doing in the south, we have seen that that is going to be the big problem—large cities will take care of it better. I was very much pleased indeed to see how the small towns showed up in this contest. I wanted also to mention a point that he briefly brought out, that is, the need of caring for breeding-places in the winter time.

In the course of the Texas work the importance of getting rid of the breeding-places in the winter time seems to me to be very great. We have found that by a thorough cleaning-up in the winter we could do very much more than we could by continuing the work during the summer only.

MR. E. P. FELT: How about disposal of manure containing over-wintering pupæ?

MR. E. G. TITUS: Manure has been carried some distance from the town and we have fairly good assurance that the flies will not come back in the spring. We found some that would go through the winter in the pupal state and these appear to be destroyed when the manure is properly scattered. Where possible the manure is taken out and scattered in fields and we found we could accomplish fairly complete destruction. In other cases, the manure was piled in ricks in the field.

MR. E. P. FELT: Does that hold true in the north where they are frozen up?

MR. E. G. TITUS: I couldn't say, but I think that by breaking up the manure and scattering it over the ground you will destroy many of the puparia. We found them hibernating in piles against barns and other protected places, and by cleaning those out you can greatly aid the matter.

MR. E. N. CORY: I would like to have your opinion of the distance that flies will travel.

MR. E. G. TITUS: We marked somewhere between seven thousand and eight thousand flies the last few years and then hunted for them afterward. We found a few of them but I found no flies at any time a half a mile away from the place where they were liberated.

In Salt Lake City, Utah, there was complaint that flies were coming from the city dumping-ground. You remember our Salt Lake blocks are large and four of them would make a pretty good-sized distance to walk. In the country we found the same thing, where we took them out into the farm region and liberated them in the pastures, and under those conditions we never found any that would reach beyond half a mile. Now perhaps our conditions are different; the dry air may have something to do with it, and I would like to hear if anyone has done anything on that line. It is quite essential on our end of the work on the fly.

MR. T. J. HEADLEE: Mr. C. H. Richardson of our department carried on some flight experiments during the past season. Flies marked in various ways were liberated at a distance of 1,715 feet from the pig barn on the college farm at New Brunswick. About three thousand individuals were liberated at a time in one place and in most of the trials from ten to fifteen marked flies were recovered in the traps at the pig barn.

MR. C. GORDON HEWITT: As Professor Titus has raised the question of the flight of the house-fly, I should like to give my own experience in the matter; as important results were published in a report by the British Local Government Board, on the carriage of infection by flies. Two or three years ago I had some experiments carried out in the city of Ottawa to study the flight of flies under city conditions. Flies were bred out and then marked with rosalic acid. They were liberated at a given point in a fairly well-inhabited region, throughout which Tanglefoot papers were distributed in the houses. These Tanglefoot papers were collected from day to day. Out of the 13,500 flies that were liberated, 172 marked flies were recovered at varying distances from the point of liberation, the farthest being 700 yards. In a further report of the British Local Government Board, experiments carried out by Copeman, Howlett and Merriman in Norfolk, England, demonstrated that under rural conditions flies travel from three hundred to seventeen hundred yards from the refuse in which they are bred; their flight depending largely on the prevailing winds. Experiments are recorded by Nuttall, Merriman and Hindle who carried on experiments under urban conditions in Cambridge, England, which bear out on the whole the limited range of flight of flies under city conditions. I think those interested would do well to consult these reports, which I think could be easily obtained.

PRESIDENT H. T. FERNALD: The next paper will be read by Glenn W. Herrick.

ADDITIONAL DATA CONCERNING THE CONTROL OF THE FRUIT-TREE LEAF-ROLLER IN NEW YORK

By GLENN W. HERRICK

During the past three years the fruit-tree leaf-roller, *Archips argyrospila*, has been exceedingly abundant in parts of New York State and has caused serious losses to fruit-growers. In the spring of 1912 an extensive series of experiments in an orchard in Genesee County was conducted in an attempt to control the leaf-roller by destroying the larvæ with poison and contact sprays. In all, over seventeen combinations of materials were tried on different groups of trees in the orchard. Most of the applications were made before the cluster of flower buds had separated. At this time, however, a large part of the eggs had hatched and many larvæ had already worked their way down among the cluster buds and were feeding on the buds and bud stems.

The results of the whole series of experiments were really very discouraging so far as prevention of injury to the fruit was concerned.

There was so little difference between the sprayed and unsprayed portions that it did not seem worth while to make a count of the fruit. The orchard produced only about two hundred and fifty barrels of apples out of a normal eight hundred barrels and these were mostly in the tops of the trees and in portions of the orchard not so badly infested. In this connection, the work of one of the better and more intelligent fruit-growers in New York is of interest.

The large orchards in question were sprayed five times and sprayed thoroughly and intelligently. The orchards were sprayed first, in the dormant condition, just before the buds burst, with lime-sulphur, 1 gallon to 6½ gallons of water with 1 pint of black-leaf-40 to every 100 gallons for the aphis. The second spraying was made just before the blossoms opened with lime-sulphur 1 to 50 and 3 pounds of arsenate of lead. The third application was made just as the petals had fallen and consisted of lime-sulphur 1 to 50, arsenate of lead 3 pounds and black-leaf-40, ¾ pint to 100 gallons. A fourth spraying was made about 10 days to two weeks after the third with lime-sulphur 1 to 50 and 3 pounds of arsenate of lead. At about this time the owners became much worried about the roller and sprayed a fifth time with arsenate of lead alone, 4 pounds to 50 gallons. In spite of this extraordinary amount of careful and thorough spraying, the trees and cover crop under the trees were alive with larvæ and 40 per cent of the crop was ruined.

Gillette and Weldon performed a series of experiments in Colorado in 1912 in an attempt to control the leaf-roller by the use of poison sprays.[1] The first spray was applied May 5. The cluster buds had separated but the buds had not begun to open up. At this time "practically every blossom bud picked had from three to five larvæ feeding in it." They estimated that 75 per cent of the larvæ were killed by this and succeeding applications. Unfortunately 25 per cent, where the larvæ are multitudinous, is quite sufficient to cause disastrous results. The question, of course, arises as to whether the remaining 25 per cent can be caught before they enter the buds or get out of the way of the poison. Mr. J. B. Gill, in his thorough work in New Mexico and Canon City, Colo., found that "applications of arsenicals alone and in combination with 40 per cent nicotine solution have greatly reduced the amount of injury to the fruit and foliage, but these sprays have not been so effective as desirable." On account of the long period of egg-hatching it is almost impossible to poison the larvæ before they become safely hidden. Especially is this true in case of late varieties of apples.

[1] 1912, Circular 5, Colorado Experiment Station.

In conclusion of this brief consideration of the poison sprays it should be said that in every case much benefit was derived from them in protecting the foliage and enabling the trees to develop fruit buds for the subsequent season. Nor is this to be considered of little moment or of slight importance. At the same time, fruit buds are of little value if they are so eaten by insects that they cannot develop into fruit.

Experiments with Miscible Oils to Destroy the Eggs

In the spring of 1913 we planned and carried out a series of experiments in a badly infested orchard with the miscible oils, using Scalecide and the Orchard brand manufactured by the Thompson Chemical Company. In all, thirty large russet trees were included in the experiment and carefully sprayed with the oils at the proportions of 1 to 15. In addition to these trees included in the actual experiment many more were sprayed by the owner with Scalecide at the rate of 1 gallon to 15 gallons of water.

The oils were applied April 2 and 3, of course, before the buds had started, although they had begun to swell. Unfortunately, it rained hard in the afternoon of April 3 and the oil applied that morning had been on only four hours, while the oil applied the day before only about twenty-four hours. Undoubtedly this influenced the final results.

On May 13, I made a rather extensive and tedious count of the eggs killed by the oil in different masses. In the experimental rows the masses were taken mostly from the row that was sprayed in the forenoon of the day on which it rained in the afternoon. We were not aware of this until we consulted our notes later. The results of the count showed that a fraction over 76 per cent of the eggs had been destroyed and did not hatch. In that part of the orchard sprayed by the owner a more extensive count of egg masses showed that practically 79 per cent of the eggs had been killed.

The general effect of the spraying with the miscible oils was better than we hardly dared hope. In the first place, there is no appearance in the orchard of injury caused by the oils. We were careful to make the applications just as near the active growing period of the trees as possible. Moreover, the spraying was done in moderately warm weather. The orchard bore a fair crop of fruit and the owner is much encouraged.

Gill, in his work in Colorado with the miscible oils killed a much higher percentage of the eggs. Gillette and Weldon in Colorado succeeded in killing 95 per cent of the eggs. From their accounts it appears that the trees were more thoroughly drenched than were the

trees we sprayed in the New York orchard. If it had not been for the fact that we feared the effect of the miscible oil sprays we should have insisted on a more thorough drenching.

Again, in 1914, a still more extensive series of experiments based on knowledge gained in the previous seasons was planned and carried out in coöperation with two growers at Hilton, N. Y. Mr. R. W. Leiby was placed in charge of these field experiments and to his thorough and careful work we are greatly indebted for our results.

Briefly, three brands of miscible oils were used in a preliminary way on small areas in which the results could be accurately checked by careful counts of eggs, hatched and unhatched. In cage experiments carried out indoors Target brand killed 94.7 per cent of the eggs while Scalecide killed 96.2 per cent. In the check, 95.75 per cent of the eggs hatched.

In outdoor experiments confined to a few plum trees on which the egg masses were located and marked by tying strips of white cloth about the branches, Target brand at 1 to 20 killed 92.6 per cent of the eggs, Scalecide, at 1 to 15 killed 91.2 per cent and Orchard brand 87.4 per cent. The average for the three oils was 90.4 per cent. Very likely these egg masses being so conspicuously marked were more thoroughly treated than would be the case in ordinary orchard spraying. The results in the main orchard would indicate this.

In the main orchard, sprayed by the owner in the ordinary way, yet thoroughly, an extended count of egg masses showed that an average of 85+ per cent of the eggs were destroyed. In general orchard spraying it is an exceedingly difficult matter to hit all of the egg masses or to thoroughly wet all that are touched with the mixture. It is doubtful if the average grower will be able to kill over 85 per cent of the eggs on large apple trees for the simple reason that some of the masses will not be actually hit with the liquid. If, on the average, 85 per cent of the eggs can be destroyed with the miscible oils they will constitute a most efficient check against serious infestations of the leaf-roller.

We did not, however, rely on the miscible oils for the complete control of this insect in the orchards under consideration. We planned to supplement the oils with arsenate of lead and on May 7, the next day after the eggs began to hatch, the orchards were sprayed with the poison at the rate of 3 pounds to 50 gallons of water. The buds had just begun to burst and two or three leaves had separated.

A second application of lead in the same proportions was made on May 14 just before the blossom buds had separated. Finally on May 26 the first codling moth spray was applied. The results were very satisfactory and the owners feel that they can control the leaf-roller.

Their feeling of great discouragement produced by the conditions in 1913 has changed to a hopeful and confident assurance that the problem has been solved.

In some field experiments which cannot be detailed here we were unable to control the leaf-roller to any degree of satisfaction by omitting the application of oils.

Finally, in our treatment of hundreds of apple, pear, plum, and cherry trees not a single case of injury has been found from the effects of the oils. In addition, many barrels of oil were applied last spring throughout western New York and so far as we have personally examined the treated orchards or have been able to talk with the owners of treated orchards we have not found any injury. It should be noted, however, that the oils were applied in the spring and only after the trees had become more or less active or very near the time of the beginning of activity. Moreover, we were afraid of the oils and constantly warned the owner in his general orchard spraying to be careful and not drench the trees. Had the oils been applied more liberally and had the trees been more thoroughly drenched, probably a higher per cent of eggs would have been killed. The owner declares that next year he is going to apply the oils at the rate of 1–12 and that he is going to soak his trees. We have assured him that he will do so on his own responsibility. Undoubtedly Dr. Felt has given us abundant proof that these oils do, under certain conditions, produce an injurious effect. Unfortunately, we do not know just what those conditions are.

To sum up then, our experiments seem to show that the leaf-roller can be satisfactorily controlled by an application of miscible oil to destroy the eggs, supplemented by thorough sprayings with arsenate of lead.

MR. E. P. FELT: I am very glad to have this data, and particularly that in relation to the miscible oils, because the results as noted by Professor Herrick agree quite closely with what I think those oils will do when we make careful application.

MR. W. W. YOTHERS: This subject has been quite thoroughly worked out in Florida during the past five years. The results in Florida show that the injury which follows the use of several miscible oils can be attributed to the chemicals which these insecticides contain and not to the oil itself. Dr. A. W. Morrill found that Orchard brand was very injurious to citrus trees. The present investigation experimented with this insecticide extensively and found independently that it was exceedingly injurious and that it could not be used on citrus at any time of the year. The Bureau of Chemistry analyzed this

insecticide and found that it contained 2½ per cent of sulphuric acid and I inferred that this chemical was the cause of the injury. I regret to state that I found it impossible to introduce sulphuric acid in any of the formula with which I experimented and therefore I was not able to test any formula with and without sulphuric acid.

In regard to Scalecide, it is not so injurious to citrus fruits as Orchard brand but it does so much damage to young fruits that it is inadvisable to use it at any time of the year. The Bureau of Chemistry found that this insecticide contained much rosin or rosin oil. In other experiments with the use of rosin and rosin oil, in every instance the same formula made up with rosin oil caused much damage while the same formula with rosin oil omitted was absolutely harmless. I have concluded that an insecticide for use on citrus trees should not contain rosin oil.

Target brand is fairly efficient. It contains quite a large percentage of phenol which my experiments show is worthless as an insecticide and is more or less injurious to the trees and the fruits. It is much less injurious than either of the former articles and is used quite extensively throughout the state.

Schnarr's Insecticide is also a proprietary article and does not contain any of the above injurious chemicals and as a general proposition it does no injury to fruit or trees. Neither does the Government formula which contains none of these chemicals cause any damage to the trees or fruits if used conservatively. Thousands of gallons of these paraffin oil emulsions have been used with little or no damage.

It is my contention that if oils containing these injurious chemicals cause injury to citrus then there is also great liability that they will cause injury to deciduous trees. I think it would be a matter worth while to experiment with some of the cheap paraffin oil emulsions on deciduous trees to determine if any injury or liability to injury would follow their use. I suppose it is generally understood that miscible oils can be made from cheap lubricating oils which can be found almost everywhere and cost about fifteen cents a gallon in barrel lots.

MR. E. G. TITUS: Only in the last three years have we had any damage from this particular insect. At the present time, it has seriously infested some of the fruit orchards in two of our valleys.

This year I carried on some spraying experiments and my results are not as good as I expected them to be.

The leaf-roller injures from 50 to 60 per cent; this injury was reduced to 24, 11 and 7 per cent, roughly speaking, but even 7 per cent injury is too great to allow the leaf-roller and we wish to improve. If

anyone has been successful with miscible oils and not injured trees, I would like to hear from them.

MR. C. P. GILLETTE: I am very much interested in the paper just read, because the results seem almost identical with those we had in Colorado, especially with the arsenical sprays. We came to the conclusion that it was almost useless to expect the ordinary fruit-grower to control the leaf-roller by means of arsenical sprays. It is necessary to make so many applications in order to keep the young leaves well covered with poison that we seldom find the grower thorough enough to get good results. For that reason, in the Canon City district, where the insect had become very destructive, we insisted upon the use of the oil sprays. We used "Target brand" almost entirely, and got excellent results. Where the growers failed, it was because the orchards were not well treated with the oil.

VICE-PRESIDENT GLENN W. HERRICK: Aren't your trees generally smaller than ours in New York State?

MR. C. P. GILLETTE: I think not. We sometimes gather 40 or 45 bushels of apples from one tree. I believe in Colorado, we have one advantage over the east and the south in our dry climate; it is nearly always bright and clear so that the oil evaporates quickly. In a moist climate the danger of injury from the use of oils is probably greater.

PRESIDENT H. T. FERNALD: The next paper on the program will be by E. N. Cory.

PRELIMINARY REPORT ON THE WOOLLY APHIS[1]

By E. N. CORY, *College Park, Md.*

The results herein set forth, as the title indicates, are wholly preliminary. To the author they are in no sense conclusive, but the facts seem to warrant the belief that other experiments along similar lines may lead to a method for the control of the woolly aphis.

Because the nursery injury was the most apparent, the control of this pest was confined for a time, chiefly to nursery stock. This experimentation was begun in 1908, and has been continued as time and circumstances allowed.

This work has never been pursued thoroughly and continuously to a definite conclusion because other, apparently more important, work has always intervened. For the most part we have been content

[1] *Schizoneura lanigera* Hausm.

to advise the use of the remedial measures generally recommended. Two main lines of work have been followed, treatment of the soil with dust applications and spraying the tops and soil about the roots. Tobacco dust of various manufacturing companies and kerosene emulsion have been the principal insecticides used. In addition, apterite (a carbolic fertilizer), nicotine sulphate, fish oil soap and lime-sulphur have been used. The usual mode of application in nurseries has been to bar plow along each side of the row, apply the dust or spray and then throw the earth back around the trees.

Thus far we have been unable to secure good results with any of the above-mentioned insecticides. Kerosene has given better results than any other insecticide. However, as this paper is concerned chiefly with results achieved in orchard work, the details of our experiments on nursery stock will be left for another time.

Treatment of Orchard Trees

As in the nursery work the control experiments on woolly aphis in orchards have been in progress for several years, without determinate results.

In the spring of 1912 work was begun in the orchard of E. W. Hungerford, Marshall Hall, Md., in testing the value of various insecticides. This orchard was selected because, first: it was badly infested with woolly aphis and second because the soil in which it is set is a sandy loam. As the soil in the college orchards is a clay loam, the sandy soil conditions gave an opportunity for some comparisons.

Eleven insecticides in the form of dust or liquids were applied in trenches dug about the base of the trees. These trenches were dug down deep enough to expose the main roots and about six feet in diameter. All trees treated were infested with root aphis.

Soluble oil, 1 to 15; Scalecide, 1 to 15; Electro Insecticide Soap, 1 pound to 4 gallons of water; Lemon oil, 1 to 24; Nico-Sul, 1 to 240; lime-sulphur, 1 to 9; undiluted Pine Tar Creosote at the rate of 1½, 2 and 3 quarts per tree, kerosene emulsion, 10 per cent; tobacco dust, 1½ to 3 pounds per tree; One for All, ½ pound to 1 gallon and Apterite 1 pound 3 ounces, 2 pounds 6 ounces and 4 pounds 12 ounces per tree. As this was a private orchard, it was not considered advisable to apply each insecticide to more than a few trees on account of the danger of injury to the trees. It was planned to continue the applications that held the most promise in the college orchards.

The applications were made June 24 and 25, 1912. During the night of the 24th rain fell and intermittently during the 25th so that the conditions were exceptionally favorable for complete penetration.

The trees were examined in the fall of 1912, without disclosing any

apparent injury. On April 18, 1913, the soil was removed from the base of the trees and a careful examination made for the presence of aphids with the following results: Aphids were found abundant on the roots of all of the treated trees except on two trees treated with tobacco dust at the rate of three pounds per tree; on one tree treated with tobacco dust one and one-half pounds per tree; on one tree treated with lemon oil; on one tree treated with Scalecide and on three trees treated with Electro Pine Tar Creosote. The probable effect of the last three solutions on the life of the tree was a matter of speculation, hence only a very few trees were treated. Only one tree was treated with each dosage of creosote.

The tests of the effieiency of the Pine Tar Creosote were continued in this orchard on other trees with ample checks. This was the only insecticide continued because, due to the circumstances detailed below, it was considered to hold the greatest promise. These tests will be discussed in a later paragraph.

During the examination it was found that a small ant was caring for the aphids quite as assiduously as they do for their young. Wherever aphids were found ants were present and they were not present in any case where the aphids had apparently been controlled.

Upon the removal of the earth from the base of the trees, an ant would seize the nearest aphid in its mandibles and immediately seek the shelter of the nearest clod or would follow the channels made in the soil by the roots to what it evidently considered a safe place, then it would hurry back for another aphid and repeat the process. This relationship was found to exist in every case where aphids were present.

Specimens of the ants were collected and sent to Dr. W. M. Wheeler, who very kindly determined them as *Lasius* (*Acanthomyops*) *interjectus* Mayr., supplementing the determination with the following interesting comments:

"This ant is a subterranean species which makes a business, like our other species of Acanthomyops, of dealing exclusively with root aphids and coccids. I have always supposed that these ants did considerable harm, because they go into this business quite extensively not only on the root of fruit trees, but also on the root of forest trees and even herbaceous plants. The workers of all the species of Acanthomyops have the curious odor which you noticed and described so well."

The relationship was so marked that the possibility of controlling the root form of the aphid by control of the ants in this orchard seemed worthy of a test. In other orchards the writer had previously noticed in searching for aphids, the peculiar odor, similiar to that of citronella, that is always associated with *L. interjectus*. Work was therefore

planned to ascertain the extent to which the ant was present as a symbiote in other orchards, particularly those set in heavier soils than that at Marshall Hall.

A large percentage of the trees in several of the college orchards have been examined for the presence of the ants. With great uniformity the trees examined showed the presence of *L. interjectus* accompanying aphids. Examinations were begun April, 1913, and continued throughout that season.

With these facts before the writer in regard to the ants and negative results from the tests at Marshall Hall and tests applied in July, 1912, in the college orchards, details of which will be given later, plans were laid for more thorough tests of the Pine Tar Creosote. A row of trees in the Marshall Hall orchard was selected and examined for aphis and ants. Both were found in numbers on every tree. Every alternate tree to the number of seven were treated with one quart of Pine Tar Creosote after the earth had been removed. Following treatment, the earth was replaced. This test was applied on April 26, 1913. Seven untreated trees were left in the row as checks. These tests were examined December 3, 1914, and they showed very encouraging results. The odor of the creosote was decidedly apparent even after twenty-one months had elapsed. Aphids were present on all of the checks except on two and no aphids were present on any of the treated trees except in one case. Ants were not present at the above date. This was to be expected owing to the late date of the observations. A note made in 1912 seems to indicate a congregating habit of the hibernating ants. During the early spring a cluster of *L. interjectus* was discovered in the cavity of an old tree. This was prior to our observation of the association of the ants with the woolly aphis, hence, no effort was made to keep notes on the cluster of ants. However this nest was just within the border of a wood that adjoins one of the college orchards wherein ants and aphis have since been found in abundance.

Thus far only the tests with undiluted Pine Tar Creosote have been mentioned. No injury to the roots or trees has been observed resulting from its use. The material is rather expensive—30 cents per gallon in quantity, hence tests were made of the material in emulsion. This was made by using two-thirds of a pound caustic soda, 90 per cent (NaOH) for each gallon of creosote. A 6 per cent emulsion was used in the college orchard in July, 1913. Eleven trees were treated in a small orchard consisting of trees grafted on American, Paradise and Doucin stocks. The trees on Paradise stock were only slightly infested with aphids, while those on the other two kinds of stocks were heavily infested. Only a few ants were present. The test was

conducted primarily to ascertain whether the 6 per cent emulsion would kill the greatest part of the aphids, and to determine the effect of the insectide on the vegetative state of the tree. Ample infested checks were retained.

Examination July, 1914, showed that while only two trees were entirely free from aphis, the balance with the exception of two trees were free from aphis where the spray influence must have been greatest, *i. e.*, near the crown. The other trees showed one or two isolated clusters of aphids far out from the base of the trees.

The application was repeated two days after the above examination and in addition eight other trees in this block were similarly treated, leaving two trees as checks.

In addition to the effect on the aphids, a most excellent effect on the vegetative state of the trees was apparent. New roots were very numerous and the old bark was replaced by new tissue. Apparently, the spray was just sufficiently injurious to the tissues to stimulate the tree to grow new roots and bark.

Kerosene Emulsion

Nine trees were sprayed July 6, 1912, with 4 gallons each of 10 per cent kerosene emulsion. The earth was removed and not replaced until July 8 owing to threatening showers, which however did not materialize. These trees were all infested. Examination July, 1913, showed every tree badly injured by the kerosene. The small roots were dead and partially decayed and the outside bark around the crowns entirely killed.

Summary

1. Of all the insecticides used Electro Pine Tar Creosote holds the greatest promise due to, first, its power to kill the aphids; second, its strong repellant action and its retention of the penetrating odor after at least twenty-one months in the soil; third, its stimulative effect on diseased tissues, and fourth, the possibility of emulsifying it readily.

2. There is a symbiotic relationship between the aphids and *Lasius* (*Acanthomyops*) *interjectus* Mayr.

There appears to be a congregating habit in *L. interjectus* Mayr., of which it may be possible to take advantage in controlling the ant.

Creosote is an effective repellant for this ant.

3. Paradise stocks show some degree of immunity to attack by the root forms of the woolly aphis.

President H. T. Fernald: The next paper on the program will be read by W. C. O'Kane.

ARSENICAL RESIDUES ON FRUIT AND GRASS

By W. C. O'Kane, *Durham, N. H.*

(*Withdrawn for publication elsewhere*)

Mr. E. G. Titus: I would like to ask a question in regard to the weak animals, as I have had occasion to examine animals with paralysis, and it has often occurred to me that arsenical poisoning might have something to do with the muscular weakness of these animals. It usually occurs in either the fore or hind quarters.

Mr. W. C. O'Kane: The poison is presumed to affect the nerve centers, resulting often in paralysis of the extremities. The calves, if they had been free, no doubt would not have eaten all the grass. They hunted around the edge of the inclosure and tried to get fresh grass. They would eat the sprayed grass freely at the start—ate it promiscuously and then apparently acquired some discernment.

Mr. H. A. Gossard: I would like to inquire whether anyone has any data showing the effect of poison on suckling animals after the mothers have fed on sprayed grass. I recollect an instance in which suckling pigs had died, their mother having fed in a sprayed orchard. The party making the report to me had inquired of a chemist who stated there was danger of the poison being transmitted through the milk, and while little injury was likely to result to the mature hog, the suckling pigs might be injured.

Mr. W. C. O'Kane: I do not know of any data in regard to farm animals that is trustworthy. There are notes as to human beings, especially in English reports of the death of babies that were nursed by mothers who were receiving small amounts of arsenic.

President H. T. Fernald: The next paper will be read by Leonard Haseman.

Mr. Leonard Haseman: This is of course not especially a Missouri pest, but the cotton moth has attracted so much attention in Missouri this year that I thought perhaps a few notes might be of interest to some of the members. Last fall the migration was much heavier than previously. In the latter part of September the migration was so heavy and the damage to fruit so great that we received a very large number of complaints and requests for treatments. As is well known, the cotton moth is able to break the skin of fruit, and it does this seemingly by means of rudimentary jaws. On examining the mouthparts of the cotton moth you will find that it has small rudiments of mandibles.

COTTON WORM

By L. Haseman, *Columbia, Mo.*

For the past three years the moth of the cotton worm has migrated northward across Missouri. In some places it has been more abundant than in others and the damage which it has done to fruits has been considerable each year. The past fall the pest was more injurious than in former years. It began to attract attention early in September and was abundant until frost. It spread rapidly across the state and in two weeks seemed to be generally distributed. In places it was so abundant as to literally cover ripening fruit in the orchard and about cider presses and at night collected about lights as I have never before seen moths collect. Everywhere the moth of the army worm was found associated with it.

Injury Done by Moth.—It is a well-known fact that this moth is able to break the skin of ripening peaches and apples and other fruits. There are cases on record where it has attacked bananas on the city market, though in such cases it very probably selects injured bananas. The moths have a voracious appetite and will feed for hours without stopping after a prolonged fast. The proboscis can be thrust into the flesh of ripe apples and peaches without any trouble and it will reach almost to the pit of an average-sized peach. As the juice is extracted a depression appears which resembles a bruise. This injured tissue is porous and in a short time decay sets in and the fruit is ruined.

Late peaches seem to be the moth's favorite food though it may also attack apples, grapes, pears, tomatoes and other fruits on the markets. In some orchards the crop of Heath Cling and other late peaches was a complete loss this fall. The moths begin feeding about sundown and often completely cover the fruits which they attack. This year they truly assumed the rôle of an important orchard pest.

Work of Caterpillar.—Missouri is not a cotton state though in a few southeastern counties a great deal of cotton is raised and the crop can be grown with profit even as far north as the Missouri river. The cotton worm was very abundant and destructive to the cotton foliage where the crop was not protected by the use of arsenicals. As the moths migrated northward they oviposited on cotton where it was to be found. At Columbia a small experimental plot of cotton was found to be severely attacked by the fifteenth of September and by the first of October the foliage was all consumed. The moths began to lay eggs as soon as they arrived and continued to do so until all the cotton foliage was gone, for on the first of October caterpillars of all ages as well as pupæ were present. Many immature caterpillars migrated in all directions and failing to find cotton died of starvation.

FOOD PLANTS.—It is said that this caterpillar will feed only on cotton. From rather extensive observations in the field and from limited cage feeding experiments I have found this to be a fact. In the field, grasses, native weeds, legumes, corn and other plants found around the infested cotton patch were left strictly alone by the migrating and starving caterpillars. In cages, alfalfa, red clover, white clover, cotton weed, morning glory, hollihock, dock were, except for an occasional hole being eaten out, refused by the starving caterpillars.

NATURAL ENEMIES.—In this latitude the winter conditions destroy this pest completely and during the summer two parasites assisted. A native ichneumon was found ovipositing in the pupæ and several were bred from pupæ. Some caterpillars were found with the eggs of a Tachina fly on them, though the species was not determined. The caterpillar is so active that it is difficult for the Tachina flies to deposit eggs on it. The boll worm was also found to attack the cotton worm in a few cases.

MR. H. A. SURFACE: I found this moth rather abundant in peach orchards last fall and saw considerable damage to Salway peaches. It was not nearly so numerous as was the case two years ago but considerable injury resulted.

MR. J. J. DAVIS: It is interesting to note that the moths seem to lay their eggs after migrating. I would like to ask if there is any data regarding egg-laying after the migratory period?

MR. LEONARD HASEMAN: We made no observations as we did not know the pest was breeding in the vicinity until we saw the caterpillars. It was the first year that we had seen these caterpillars feeding so far north.

MR. C. T. BRUES: We caught quite a number of these moths at an electric trap light at the Bussey Institution, Forest Hills, Mass., but it was impossible to secure eggs from them. They come quite regularly every few years and are apparently too much exhausted by the long flight to deposit eggs.

PRESIDENT H. T. FERNALD: A paper will now be presented by H. B. Scammell.

THE CRANBERRY ROOT WORM

By H. B. SCAMMELL, *Pemberton, N. J.*

(*Withdrawn for publication elsewhere*)

SECRETARY A. F. BURGESS: I do not care to discuss the paper, but would like to state for the information of some of the members that several cranberry bogs in Massachusetts were seriously injured

this year by the gipsy moth. There has been slight injury in previous years but the damage was serious in several cases this season.

PRESIDENT H. T. FERNALD: The next paper on the program is by W. M. Scott.

ARSENATE OF LIME OR CALCIUM ARSENATE

By W. M. SCOTT, *Baltimore, Md.*

The possibility of combining arsenic with a cheaper base than lead to produce a safe and effective insecticide for use on fruit and shade trees has no doubt occurred to nearly every economic entomologist. Calcium is the cheapest material that could be used for this purpose and calcium arsenite or arsenite of lime has been recognized as an insecticide for a number of years, but owing to its injurious effect on vegetation it never has and probably never will come into general use.

Arsenate of lime, however, is a more stable and less soluble compound and should, therefore, be less caustic in its effect on fruit and foliage. So far as the writer is aware arsenate of lime is not known in entomological literature and has never been given much consideration. I am informed by Prof. A. L. Quaintance of the United States Bureau of Entomology, that during the past three years his office has conducted spraying experiments with this material and that the results have been uniformly good, although no account of the work has yet been published. For the past two years the writer has endeavored to determine the value of arsenate of lime as a substitute for arsenate of lead and the results obtained at least indicate that this material is worthy of further investigation.

Arsenate of lime may be prepared as a monocalcium, dicalcium or tricalcium arsenate. On the dry basis tricalcium arsenate ($Ca_3(As_2O_4)_2$) contains, theoretically, 42.2 per cent lime (CaO) and 57.8 per cent arsenic oxide (As_2O_5). The material used in the writer's experiments contained 46.8 per cent lime and 47.8 per cent arsenic oxide on the dry basis, and therefore had 11 per cent more lime than would occur in the true tricalcium arsenate. It contained less than 0.05 per cent soluble arsenic oxide. On the basis of 50 per cent of water this material would contain 23.9 per cent arsenic oxide, but in preparing the paste the water content cannot well be reduced below 60 per cent without the use of a filter press.

In the experiments recorded herein the paste was prepared to contain the same percentage of arsenic oxide as is found in standard arsenate of lead, *i.e.*, from 15 to 16 per cent. The rate of dilution for both materials was 2 pounds to 50 gallons of water which gave the same arsenic content in both kinds of diluted sprays.

During 1913, in the Rockfish Valley Orchard, at Ayon, Va., 50 Winesap and Yellow Newtown apple trees were sprayed four times with arsenate of lime following the usual schedule, and the remainder of the orchard was sprayed with arsenate of lead. With both poisons, lime-sulphur solution was used as a fungicide in all the applications except the last, in which Bordeaux mixture was used.

The trees were examined from time to time during the season and no difference could be observed between the two kinds of poison, either in their effect on the fruit and foliage or in the control of the codling moth and other insects. No injury was produced and the codling moth was controlled equally well in both cases.

During 1914 a similar experiment on a larger scale was conducted in the same orchard. About 200 Winesap apple trees were sprayed with arsenate of lime and a like number with arsenate of lead and 5 trees were left as checks. As a fungicide lime-sulphur solution was used with the arsenicals and the trees were sprayed (1) after the blossom buds separated, showing pink, (2) as soon as the petals fell, (3) three weeks later and (4) about nine weeks after the petals fell (the first week in July).

Although no actual counts were made it was estimated at picking time that about 60 per cent. of the fruit from the unsprayed trees was infested with the codling moth. The fruit from the adjacent trees of the sprayed plots was reasonably free from this insect and no difference could be noted in the efficiency of the two kinds of poison. At the opposite end of the orchard from the check trees, however, the codling moth was not so well controlled and the superintendent was of the opinion that the arsenate of lead had given slightly better results than the arsenate of lime.

In a similar experiment conducted in an apple orchard near Hancock, Md., the powdered form of arsenate of lime was used and here again this poison proved to be the equivalent of arsenate of lead.

During the past spraying season (1914) several apple growers cooperated with the writer in testing this material and, as shown by the following reports, uniformly good results were obtained.

Mr. Fred Johnson, a member of this association and formerly an assistant in the United States Bureau of Entomology, used 50 pounds of arsenate of lime in his orchard at Westfield, N. Y., and in a letter to the writer dated September 28, 1914, he made the following statement in regard to the results:

> I would say that we used this preparation (barium-sulphur crystals) together with the arsenate of lime on three rows of Baldwin trees in one of our orchards at the strength you recommended. All the rest of the orchard was sprayed with home-prepared lime-sulphur and arsenate of lead. This season the whole orchard is as entirely free from scab and codling moth as I could wish, so you may judge that the

results are well nigh perfect. I made several close examinations of the trees sprayed with the dry material and the arsenate of lime and from these observations could see no difference in results from adjacent trees sprayed with the standard formula.

Mr. W. F. D. Batjer, secretary of the Northwest Arkansas Fruit Growers Association, used 50 pounds in his orchard at Rogers, Ark., and under date of November 5, he made the following favorable report on the results:

I used this material on a block of Bens and Ganos in connection with lime-sulphur for the cluster bud, calyx and ten-day spray; on the rest of my orchard I used arsenate of lead in both dry and paste form. The entire crop was remarkably free from curculio and codling moth injury, the arsenate of lime block showing up fully as well as the balance in this respect. One thing that appealed to me in using the arsenate of lime was the fact that it did not change the color of the lime-sulphur solution, leaving it a clear bright yellow, and in my opinion the fruit and foliage in this block had a much better and brighter appearance throughout the season than did that in the balance of the orchard.

Mr. T. W. Ayers, formerly an assistant in the United States Bureau of Plant Industry, used 50 pounds of this poison in an apple orchard at Fort Payne, Ala., during the past season and he has reported that no difference between this material and arsenate of lead could be noted in the control of the codling moth or in their effect on the fruit and foliage.

Through the coöperation of several park commissions and public tree sprayers we were able to have arsenate of lime tested in New England for the control of shade tree insects, and 2,000 pounds were distributed for this purpose. So far as could be learned from reports received the arsenate of lime had the same killing effect on the gipsy moth and brown-tail moth as the arsenate of lead, and there was no injury to foliage reported. In one report it is stated that oak trees were sprayed with this poison for the control of brown-tail moth and that the killing effect was "very good" comparing "favorably" with arsenate of lead. Another report shows that it was used on white oak, red oak and chestnut with results "about equal to arsenate of lead" and with "no injury to the foliage."

On July 1, 1914, the writer had an opportunity to see the results of one of these experiments on the grounds of the Metropolitan Park Commission near Boston, Mass. A clump of small poplar trees infested with the gipsy moth had been sprayed with arsenate of lime and the ground was well covered with dead caterpillars. There were a few live caterpillars still feeding on the sprayed leaves but no larger per cent than was found on adjacent trees sprayed with arsenate of lead.

At Hancock, Md., during the past season the writer used arsenate

of lime on peach trees as a foliage test and found that at a dilution of 1½ pounds (16 per cent arsenic oxide) to 50 gallons of water it almost defoliated the trees. Arsenate of lead used on the same variety caused very little injury, although this arsenical has been known to seriously injure peach foliage under certain weather conditions. It is evident from this test that arsenate of lime is more likely to injure susceptible foliage than arsenate of lead.

It appears from the results of these various experiments that for spraying apple and shade trees arsenate of lime may be used with the same degree of efficiency and safety as arsenate of lead. The chief advantage it has is in the matter of cost, being cheaper than arsenate of lead. It mixes with lime-sulphur solution without causing any chemical reaction which fact might be considered as another advantage, neither material being decomposed by the combination. Unless some unsuspected objection to this new insecticide develops, it would seem a waste of money to continue the use of the more expensive poison.

MR. GLENN W. HERRICK: I would like to ask how much this poison can be sold for?

MR. W. M. SCOTT: I cannot answer that question definitely except that there ought to be about the same difference in the cost of arsenate of lime and arsenate of lead as there is in the cost of the lead and the lime used in their preparation, although I have no figures on the cost of manufacture. It is perhaps needless to remark that this paper is not given for advertising purposes because arsenate of lime can be made by anyone; in fact the fruit-grower can make it in his orchard.

SECRETARY A. F. BURGESS: Last spring we secured a barrel or two of arsenate of lime and several areas were treated by Mr. Worthley's men. I would like to ask him to make a statement in regard to the amount of poison used and the general results of the spraying.

MR. L. H. WORTHLEY: We used about two hundred pounds of poison at the rate of 10 pounds to 100 gallons of water. The results from the standpoint of destroying caterpillars was as good as when arsenate of lead was used, but considerable burning resulted to some of the trees, especially cherry, apple, oak, maple; although almost every species treated showed some burning.

MR. A. L. QUAINTANCE: Mr. Siegler of the Bureau of Entomology has been working with arsenate of lime, especially as to its home preparation, and I shall be glad if he will state briefly some of the results.

MR. E. H. SIEGLER: We have been using arsenate of lime in various

forms, beginning in 1912, for the control of the codling moth and other deciduous fruit insects. During the season of 1914, a commercial arsenate of calcium (paste) containing 18 per cent arsenic oxide (As_2O_5) was tested against the codling moth in our experimental apple orchard, Benton Harbor, Mich. This was used at the rate of 2 pounds to 50 gallons of lime-sulphur solution in comparison with arsenate of lead paste, used at the same rate, combined with lime-sulphur solution. Three spray applications were made: (1) When the petals dropped. (2) Three to four weeks later. (3) Nine weeks after falling of the petals for the control of the second brood.

The arsenate of lime plat included 10 trees, the fruit from 5 of which was examined as it dropped during the season and again at harvest time. The arsenate of lead plat contained 12 trees—6 examined. The unsprayed plat consisted of 8 trees, the fruit from each tree being examined. Each plat produced approximately forty barrels of fruit at harvest, which was inspected for codling moth injury. The arsenate of calcium and arsenate of lead plats gave over 98 per cent of fruit free from the codling moth, while the unsprayed plat yielded about 59 per cent of fruit free from this injury. The foliage of the arsenate of lime plat compared favorably with that of arsenate of lead throughout the season.

We have prepared arsenate of lime by adding sodium arsenate to slaking lime. This arsenical may be prepared from other chemicals, such as a combination of arsenic acid and lime. According to our figures, a good arsenate of lime paste may be made at a cost of two to three cents per pound, exclusive of labor. We have recently purchased fused sodium arsenate (65% As_2O_5) at 8½ cents per pound and stone lime at 75 cents per barrel. From these materials we have made arsenate of lime paste, containing over 20 per cent arsenic oxide, at a cost not to exceed 3 cents per pound. The biproduct, sodium hydroxide, if not removed, may injure delicate foliage. Most of the sodium hydroxide, however, may be readily decanted.

Arsenate of lime was made in the same operation of slaking the lime for Bordeaux mixture for use in an experimental vineyard. No foliage injury resulted.

Arsenate of lime has not been tested sufficiently to warrant an unqualified recommendation. This arsenical may have certain limitations, but it is apparently a promising and cheap insecticide.

MR. W. C. O'KANE: I would like to ask Mr. Scott whether he has any determination showing the soluble arsenic in the material. You state that there is sometimes burning of foliage and sometimes not. If the free arsenic is a variable quantity, it seems to me that the material offers some risks in its effect on the plants sprayed.

MR. W. M. SCOTT: The material used in my experiments ran from a trace of soluble arsenic up to one-half of one per cent. It was uniformly lower in soluble arsenic than arsenate of lead.

PRESIDENT H. T. FERNALD: The last paper on the program will be read by Mr. H. A. Surface.

FRAUDS, SEMI-FRAUDS AND QUESTIONABLES

By H. A. SURFACE, *Harrisburg, Pa.*

(Withdrawn for publication elsewhere)

PRESIDENT H. T. FERNALD: If there is no discussion, we will now adjourn.

Adjournment, 6.00 p. m.

Afternoon Session, Wednesday, December 30, 1914; 2.00 p. m.

PRESIDENT H. T. FERNALD: The first paper on the program will be read by V. I. Safro.

THE NICOTINE SULPHATE-BORDEAUX COMBINATION

By V. I. SAFRO, *Louisville, Kentucky*

A considerable item of expense in spraying operations is the cost of application. Growers will frequently hesitate to spray, not on account of the cost of the material, but because of the necessity of an additional application. "Fewer applications," is the demand of the grower today in his spraying practice. In choosing one of several materials for spraying, the answer to the question, "Can it be used in combination with other sprays?" will often determine the cheapest spray, and not the cost of the material per gallon. A spray may cost more per gallon but be cheaper in that it does not require a separate application.

In attempting to ascertain the status, last spring, of the advisability of combining Nicotine Sulphate with Bordeaux, we found that there was no consensus of opinion in the matter; in most cases, in fact, the attitude was taken that the combination should not be used on account of possible injury to foliage. This attitude was conservative and proper in that new combinations should not be recommended as long as reasonable doubts exist as to their effectiveness.

THE PROBLEM.—Three questions arose regarding the possible results of combining Nicotine Sulphate with Bordeaux Mixture.

1. Is free copper sulphate released as a result of the combination?
2. Does the nicotine sulphate decompose in such a combination?
3. Is the nicotine in the combination precipitated?

The first question would indicate the bearing of the combination on the production of leaf injury.

The second and third questions would, perhaps, indicate the modification in the insecticidal properties of the nicotine in the combination.

COPPER SULPHATE NOT RELEASED.—The 4-4-50 formula was used in making up the Bordeaux for the experiments. The chemical experiments were duplicated with commercial Bordeaux paste with results similar to the results recorded below with home-made Bordeaux. A commercial preparation of Nicotine Sulphate, containing 40 per cent nicotine, was used at dilutions of 1 to 800 and 1 to 1000.

Bordeaux injury on the fruit or foliage is caused by free copper sulphate. In our experiments we used the potassium ferro-cyanide test for free copper sulphate in the Bordeaux before and after the combination with Nicotine Sulphate. The tests were made immediately after combining the two, and one, two and three days later. In none of these cases was free copper sulphate present. To ascertain whether the indicator retained its properties in the combination, some free copper sulphate was added and its presence immediately shown by the dark reaction with the potassium ferro-cyanide.

NO LEAF INJURY.—Field tests on a small scale were carried on in which Bordeaux 4-4-50, used alone and in combination with Nicotine Sulphate, 1 to 800, were sprayed upon foliage. These tests were conducted on August 16. It is true that foliage-spraying tests carried on so late in the season would not be conclusive in that the same degree of resistance to spray injury does not hold throughout the growing season. However, the plants sprayed included some with tender foliage, and the results may be taken as supplementary to the laboratory findings and the records of other workers. The foliage of the following plants was sprayed: Apple, pear, peach, sweet cherry, sour cherry, black walnut, rose, bean, tomato.

The foliage was examined at intervals of several days—the last examination being made on September 4—almost three weeks after the first application.

Another set of foliage on the same species of plants was similarly sprayed on August 22. In neither case did leaf injury result.

During the period the daily maximum temperature ranged from 75° to 94° and the minimum from 61° to 76°. For four days following the first application there was no rain and for two days following the

second. On nine days the precipitation ranged from .02 to 1.33 inches. In other words, the variations in weather were sufficient for leaf injury to become evident within the three weeks during which the plants were under investigation.

NICOTINE SULPHATE NOT DECOMPOSED.[1]—Two hours after making up the Nicotine Sulphate-Bordeaux combination it was analyzed for nicotine. The chemical record follows:

"The percentage of nicotine, by calculation, in the Nicotine Sulphate-Bordeaux mixture should be 409/10,000 of 1%. (19.255 grams of Nicotine Sulphate —41% nicotine by gravimetric analysis, containing 7.8945 grams of nicotine, were added to 19255 grams of Bordeaux mixture. This gives a calculated percentage of 409/10,000 of 1%).

"The nicotine was distilled from a weighed quantity of Nicotine Sulphate-Bordeaux mixture with steam after the addition of Caustic Soda. The Nicotine in the distillate obtained was determined by the regular Gravimetric Method.

"The actual analysis gives the nicotine content to be 413/10,000 of 1%."

All the nicotine, apparently, was recovered from the combination.

NICOTINE NOT PRECIPITATED.—The chemical record follows:

"A portion of the Nicotine Sulphate-Bordeaux mixture was removed, filtered and washed with distilled water. The filtrate was tested for nicotine, and washing continued until no more nicotine passed through the filter.

"(50 c.c. of original Nicotine Sulphate-Bordeaux was used; the wash water amounting to about 400 c.c., used in portions of 40 c.c. each.)

"The filter paper with its copper precipitate was introduced into a distilling flask, caustic soda added, and steam distillation conducted as in regular nicotine distillations.

"The distillate was tested for nicotine with Silicotungstic Acid and not the slightest precipitate was obtained.

"(Silicotungstic Acid will show a precipitate with nicotine in a dilution of one in 300,000.)".

INJURY FOLLOWING THE COMBINATION EXPLAINED.—Instances have been reported in which foliage injury followed the use of the combination, and these cases of injury were often the bases of recommendations to apply the two sprays separately.

The cases of injury apparently belong to the same category as the injury sometimes following the combination of Nicotine Sulphate with lime sulphur or with arsenate of lead or arsenite of zinc. The latter combinations are widely recommended; still, occasional reports of injury are heard. These cases are perhaps explained, as far as the combination itself is concerned, when we consider that under certain conditions lime sulphur, arsenate of lead and arsenite of zinc will cause injury even when used alone. As is well known, the same holds true of Bordeaux mixture. In none of the cases of reported injury have we

[1] The nicotine determinations in these experiments were made by Mr. H. K. McConnell, Assistant Chemist of The Kentucky Tobacco Product Co.

been able to find that Bordeaux alone had been used at the same time and under the same conditions. In other words, though Nicotine Sulphate may be used in combination with Bordeaux, it will probably not prevent any injury that the Bordeaux would cause if used alone. This fact, however, need not affect the recommendations for combining the two sprays.

SUCCESSFUL USE OF THE COMBINATION BY OTHERS.—Though the general attitude was conservative and the combination not generally recommended, records of its successful use were beginning to accumulate.

A few of the following records were published, but most of them were obtained through correspondence in answer to letters of inquiry. (This is not intended as a complete list but includes merely instances that have come to our attention.)

Professor Watkins, University of Illinois, has used the combination for five years with excellent results.[1]

W. B. Parker, Bureau of Entomology, used the combination for the hop flea beetle in 1909. No leaf injury was reported and the insecticidal properties of the combination were retained. The author considered that where the beetles were numerous and a large percentage around the vines, a Bordeaux-tobacco mixture should prove effective.[2]

Fred Johnson, Bureau of Entomology, used the combination successfully in 1911 on nymphs of the grape leaf hopper.[3]

Hartzell, New York Experiment Station, used the combination successfully for the nymphs of the grape leaf hopper in 1912.[4]

Beach, Iowa Experiment Station, in 1912 recommended the combination and that soap be not used with it.[5]

Sanderson,[6] in his book "Insect Pests of Farm, Garden, and Orchard," states that tobacco extracts may be added to Bordeaux mixture to save a separate application.

G. P. Gray, Chemist, California State Insecticide Laboratory, examined our laboratory methods and records and stated that the experiments seemed to be quite conclusive. Professor Gray's tests showed that no soluble copper was produced by mixing Bordeaux with the ordinary tobacco extracts found upon the market.[1]

Professor M. B. Waite tested the combination last summer on cantaloupes on his own farm. No foliage injury occurred and the Bordeaux

[1] In correspondence.
[2] Bureau Entomology, Bul. 82, pt. IV.
[3] Bureau Entomology, Bul. 116, pt. I.
[4] New York (Geneva) Station Bul. 359.
[5] Iowa Station Bul. 127.
[6] Page 608.

and Nicotine Sulphate were apparently as effective as if they had been used separately.[1]

H. A. Gossard, Ohio Experiment Station, states that the combination has been used on grape foliage with no bad results by coöperators of the Station.

H. S. Price, Horticulturist, Virginia Experiment Station, states that as a result of experiments in Virginia they believe that the combination may be used without danger of burning foliage and without lessening the insecticidal value of the tobacco extract.[1]

Similar tests and results were obtained by T. J. Headlee, New Jersey Experiment Station.[1]

H. F. Wilson, Oregon Experiment Station, conducted a number of experiments with the combination and found that the insecticidal value of the Nicotine Sulphate did not seem to be at all impaired. No injury was caused by the application.[1]

Miscellaneous Remarks.—It should be noted in our experiments that we used commercial Nicotine Sulphate. *Free* nicotine will combine with free copper sulphate, precipitating the *copper*. We have not investigated the result of adding *free* nicotine to Bordeaux and are not in position to make any statements concerning the safety of such a combination.

It has been stated by Professor Gray and others that the possibility existed that certain nicotine preparations containing much extractive matter would tend to dissolve the copper of the Bordeaux mixture. We have not investigated this matter and have no data bearing upon this phase of the problem.

At this point we would state that the terms "tobacco extract" and "nicotine solutions" are not synonymous. The term "tobacco extract" is understood by the trade to mean an aqueous extract of tobacco which therefore necessarily contains the water soluble ingredients of tobacco. "Nicotine solutions" are understood by the trade to mean more or less highly concentrated solutions obtained by processes other than aqueous extraction.

Conclusion.—These results and records indicate that Nicotine Sulphate may safely be added to and applied with Bordeaux in all cases where Bordeaux alone may be safely used.

President H. T. Fernald: The next paper on the program is by P. J. Parrott and W. J. Schoene.

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[1] In correspondence.

THE INSECTICIDAL PROPERTIES OF VARIOUS SULPHIDES AND POLYSULPHIDES

By P. J. Parrott and W. J. Schoene

(*Abstract*)

Recent years have witnessed the appearance on the market of a large number of spraying mixtures which derive their efficient properties from sulphides and polysulphides of sodium, potassium, calcium and barium. Most of these are in liquid form, but three preparations in a powdered or granular state, containing sulphides of sodium, potassium and barium respectively as their chief constituents are now offered for sale. It appears that methods for obtaining calcium sulphides in dry form have been devised, but so far only liquid preparations of these compounds are handled by dealers in spraying supplies. The amount of sulphur in proprietary insecticides containing sulphides and polysulphides of the different bases varies greatly, ranging for the sodium preparations from 1.79 to 58.92 per cent; potassium, 2.39 to 38.72 per cent; calcium, 3.97 to 26.40 per cent, and barium 16.54 to 44.0 per cent.

The variation in amounts of sulphur in the commercial mixtures reveals a need of definite information as to the comparative insecticidal properties of the foregoing sulphides as a basis for safe and specific recommendations. To obtain data as to the relative merits, experiments have been conducted for the past two years in which the compounds have been tested on the basis of their sulphur content, the sulphides and polysulphides of the different bases being used at varying strengths to give similar ratios of sulphur respectively in the dilute mixtures.

In experiments against the San José scale, using the compounds at the rate of four and three-fourths ounces of sulphur to a gallon, there were variations in effectiveness on individual trees, especially in apple orchards, which were, however, fairly distributed among the various plats. As gauged by blemishing of fruit, production of young scales and infestation of new wood, it was difficult to perceive that one preparation had any appreciable advantage over another. If the compounds do really differ in effectiveness, these results suggest that the differences in efficiencies are not great and apparently are such as could easily be overcome either by more thorough spraying or by slight additions to the sulphur content of the dilute mixtures or by the incorporation of inexpensive substances to increase toxic properties. The work in general so far points to the conclusion that the strength of a preparation with regard to its sulphur content is a more impor-

tant consideration than the nature of the base of the sulphides and polysulphides. On the assumption that the compounds of the different bases are equal or nearly equal against the scale, the chief factors that enter into a choice of a proprietary insecticide are safeness to foliage when combined with arsenate of lead and economy, in which respects the advantage appears to lie with the calcium and barium sprays, the former being less expensive of the two.

In tests to determine their values as stomach poisons, none of the compounds alone, apparently, including those of barium, were harmful to various species of leaf-eating caterpillers or beetles. In most instances arsenate of lead with the sulphides and polysulphides of sodium and potassium was somewhat quicker in manifesting its toxic properties than when combined with the other compounds, which may be explained by the formation of soluble arsenic in the reactions between the poison and the sulphides. Because of the chemical reactions, the sodium and potassium sulphides, while more rapid in their poisonous effects upon insects, were generally much more liable to cause injuries to the foliage of fruit trees than the calcium and barium compounds in combination with arsenate of lead.

According to their nature and mode of action, various substances are incorporated in spraying mixtures to give penetrating and adhesive properties. The agents that are commonly used are silicate of soda, saccharates, soap, glue, gelatine, resin, and home-made and commercial oil emulsions. Tests show that glue, soap, glycerine, sodium silicate and oil emulsions of various formulas may be combined with the sodium and potassium sulphides, and that similar combinations are possible with the calcium and barium sulphides-except in the case of soap and oil emulsions. As to the influence of such combinations on effectiveness, no marked results have been observed, except when soap and oil emulsions were employed with the sodium or potassium sulphides against aphides or oil emulsions with the same sulphides for the control of the San José scale. The principal gain in the latter case appears to be in an increased rate of toxicity. The destructive action of the sulphides alone on the scale is apparently slower, and while prolonged over a more extended period may, however, prove no less efficient.

PRESIDENT H. T. FERNALD: The next paper is by W. M. Scott.

A NEW CONTACT INSECTICIDE

By W. M. Scott, *Baltimore, Md.*

Lime-sulphur solution is by far the most important contact insecticide now in use, and in tonnage it probably equals, if it does not exceed, all the other insecticides, combined. It is unique in that it is both an insecticide and a fungicide and has a wider range of usefulness than any other spray material. Applied to fruit trees in the dormant season it serves to control the San José scale, oyster-shell scale and some other insects, as well as the peach leaf-curl disease. In the growing season it is used for the control of apple scab, apple leaf-spot, "red spider" and several other plant pests. It has largely supplanted the oils and soaps as scale remedies and has partly displaced Bordeaux mixture as a fungicide.

On the other hand, this material is unpleasant to prepare on the farm, bulky and heavy to transport and difficult to store without loss from leakage and evaporation. Owing to these objectionable features there has arisen a desire among fruit-growers for a "dry lime-sulphur" or a dry material that could be used as a substitute for lime-sulphur solution in the control of insects and diseases. Attempts have been made to produce such a material by reducing lime-sulphur solution to dryness, but the polysulphides of calcium upon drying decompose and become insoluble, thus largely losing their insecticidal value. Calcium thiosulphate, one of the ingredients of lime-sulphur solution, is soluble in water but experiments have shown that it is not an efficient insecticide. It therefore becomes necessary to employ some other base as a carrier for the sulphur. The results of experiments conducted by the writer during 1913 and 1914 show that barium is a satisfactory material for this purpose.[1] Professor Parrott in his paper, just presented, has shown that a solution of barium and sulphur is fully as effective as lime-sulphur solution in the control of the San José scale.

Barium and calcium belong to the same mineral group and the polysulphides of these two bases, being so closely related, might be expected to possess about the same insecticidal and fungicidal properties. One important difference in the two materials is that the polysulphides of barium, or at least one of them, can be produced in the form of soluble crystals while those of calcium cannot.

Boiling a given quantity of barium sulphide (BaS) in water with all the sulphur that it will take up produces a solution composed chiefly

[1] The chemical work in connection with these experiments was performed by Mr. C. B. Clark, a chemist of the Thomsen Chemical Company.

of barium penta-sulphide (BaS_5) which when reduced to dryness under suitable conditions forms barium tetrasulphide (BaS_4H_2O) and free sulphur. This dry material also contains some thiosulphate (BaS_2O_3). As prepared for the writer's experiments it analyzes approximately as follows:

BaS_4H_2O	85%	Total sulphur 47%
Free sulphur	7%	
BaS_2O_3	5%	Total barium 45%
Impurities	3%	

The tetrasulphide occurs in the form of reddish yellow crystals of the rhombic system and it is readily soluble in cold water. The free sulphur and thiosulphate also largely dissolve in the tetrasulphide solution, leaving about 4 per cent of the material as insoluble residue.

Spraying Experiments

During the dormant season of 1913–14 the writer conducted experiments for the control of the San José scale in Virginia, West Virginia, Pennsylvania and New York and in no case could there be observed any material difference in the killing effect of the barium product and lime-sulphur solution. The results of an experiment conducted in a ten-year-old apple orchard at Sleepy Creek, W. Va. are shown in Table I. Trees moderately infested with the San José scale were selected and the spraying was done on December 5, 1913. In making the examination on April 29 and June 8, the old weather-beaten scales that were evidently dead before the spraying was done, or that died naturally during the winter, were, of course, not counted, so that the percentages given in Table I include only those scales that could be expected, normally, to pass the winter alive.

Table I. San José Scale Experiment, Sleepy Creek, W. Va., December 5, 1913

Plot	Materials	Oz. to 1 gal. Water	Per cent Scale Dead 4-29-14	Per cent Scale Dead 6-8-14
1	Calcium thiosulphate	16	59	60
2	Calcium sulphide	6	83	90
3	Lime-sulphur sol. 33° B.	20	95	97
4	Lime-sulphur sol. 33° B.	15	93	96½
5	Barium-sulphur sol. 33° B.	20	95½	95½
6	Barium-sulphur sol. 33° B.	15	95	99½
7	Barium-sulphur sol. 33° B.	28	100	99½
8	Dry barium-sulphur	12	96	99
9	Dry barium-sulphur	12	95	..
10	Check	Unsprayed	51½	..

The barium-sulphur solution mentioned in Table I is analogous to lime-sulphur solution and was made by boiling the simple sulphide

of barium with sulphur. The dry barium-sulphur is the material already described, the chief ingredient of which is barium tetrasulphide.

It will be noted that the barium product killed the scale quite as effectually as the lime-sulphur solution, and that there was practically no difference in the effect of the dry form and the solutions. Calcium thiosulphate had no material effect on the scale, while calcium sulphide apparently did. However, these two materials were used on only one tree each which is not sufficient for conclusive results. The barium products were used on about 200 trees.

Another experiment comparing the dry barium-sulphur product with lime-sulphur solution in the control of the San José scale was conducted in a three-year-old orchard near Hancock, Md. This orchard is composed of peaches and apples interplanted, and the plots were so arranged that each contained at least one apple and one peach tree badly infested with the San José scale. About 200 trees were sprayed with the dry barium product and a like number with lime-sulphur solution. The application was made on March 25 and 26, 1914, and the trees were examined several times during the spring and summer. The results of examinations made on May 30 and July 4 are shown in Table II.

TABLE II. SAN JOSÉ SCALE EXPERIMENT, HANCOCK, MD., MARCH 25-26, 1914.

Plot	Materials	Lbs. to 50 gals. Water	Per cent Scale Dead 5-30-14	Young Alive 7-4-14
1	Dry barium-sulphur (a)	16	99½	None
2	Dry barium-sulphur	24	100	"
3	Dry barium-sulphur	32	100	"
4[1]	Lime-sulphur sol.	59	99½	"
5	Dry barium-sulphur b)	16	99½	"
6	Dry barium-sulphur	24	99½	"
7	Dry barium-sulphur	32	99½	"
8	Dry barium-sulphur (c)	16	100	"
9	Dry barium-sulphur	24	99	"
10	Dry barium-sulphur	32	100	"
11	Dry barium-sulphur	10	99½	"
12	Check	Unsprayed	50	Many

(a) represents the dry BaS_4H_2O with all the impurities, (b) the same material with most of the impurities removed, and (c) the same as (b) but prepared in a somewhat different manner.

[1] Plot 4 was sprayed with lime-sulphur solution (32°-33° Beaumé) diluted at the rate of 5½ gallons (59 lbs.) to 50 gallons of water.

As shown by the figures in Table II there was practically no difference in the insecticidal effect of the barium-sulphur crystals and lime-sulphur solution. An examination on May 30 showed from 99 per cent to 100 per cent of the scale dead on all the sprayed plots and 50 per cent on the unsprayed plot. On July 4, crawling and newly settled

young were found in abundance on the unsprayed trees, but none could be found on the badly infested trees which had been marked for examination in each of the sprayed plots. Subsequent examinations made on August 19 and November 27 showed no change in the results except that the infestation on the unsprayed trees grew steadily worse.

In 32 pounds of the dry barium product there is about the same amount of sulphur as is contained in 59 pounds (5½ gallons) of the lime-sulphur solution used and yet 16 pounds of the former material to 50 gallons of water were sufficient to control the San José scale. A dilution as weak as 10 pounds to 50 gallons of water apparently killed the scale, as shown in plot 11, but this strength was used in only the one experiment and the results should, therefore, not be considered conclusive. However, the strength of 16 pounds to 50 gallons of water was used in several different orchards with uniformly good results, which would indicate that, when combined with barium, less sulphur is required to kill the scale than when combined with lime.

An experiment for the control of the oyster-shell scale was conducted in the laboratory at Baltimore and here again the dry barium-sulphur product proved to be as effective as lime-sulphur solution. On March 3, 1914, poplar branches badly infested with this scale insect were placed in jars of water in a warm room and sprayed with these materials. A similar branch was left unsprayed as a check. The branches threw out roots from the cut surface in the water and kept alive long enough for the conclusion of the experiment. The old female scales were gorged with eggs which began to hatch on April 2, when 83 young were counted crawling over the unsprayed branch. No young were out crawling on any of the sprayed branches but by removing a few mother scales it was found that the eggs were beginning to hatch.

At the conclusion of the experiment, April 17, all of the eggs on the unsprayed branch had apparently hatched and the writer counted 300 young which had settled down and formed a scaly covering. On the branch sprayed with barium-sulphur (BaS_4H_2O+), 5 ounces to 1 gallon of water, about 90 per cent (estimated) of the eggs hatched and most of the young died without emerging from beneath the mother scales. Thirty-four young had succeeded in emerging but only two of these remained alive. On the branch treated with 7.7 ounces of barium-sulphur to 1 gallon of water, all the young died without emerging from beneath the mother scales. On a third branch treated with 10 ounces of barium-sulphur to 1 gallon of water the same results were obtained, except that 30 young emerged, all of which died without settling down. On a branch sprayed with 1 pint of lime-sulphur solution to 50 gallons of water, 300 young issued but all died without settling down.

During the growing period of 1914 spraying experiments were conducted in several apple orchards to determine the fungicidal value of barium-sulphur as compared with lime-sulphur solution. It was diluted at the rates of 3 pounds and 6 pounds of the crystals to each 50 gallons of water and was used alone, in combination with arsenate of lead and in combination with arsenate of lime. Fungous diseases, such as apple scab and apple leaf-spot, were controlled by this material to about the same extent as by lime-sulphur solution, and no injury to fruit or foliage was produced.

Also, 50 peach trees were sprayed with barium-sulphur, 3 pounds to 50 gallons of water, about three weeks after the petals fell and again one month later. Arsenate of lead (1½ pounds to 50 gallons) was added to the solution in the first application, but not in the second. No injury to fruit or foliage was produced and peach scab (*Cladosporium carpophilum*) was thoroughly controlled. This would indicate that barium-sulphur is less likely to injure vegetation than lime-sulphur solution which is known to be quite injurious to peach foliage.

MR. J. S. HOUSER: I would like to ask the cost per pound of barium sulphide?

MR. W. M. SCOTT: The cost so far as the manufacturers are concerned has not been worked out definitely. My understanding is that it will cost about four cents a pound and that at that price the original cost at the factory will be a little more than lime-sulphur solution but the difference will be made up by the difference in freight.

One thing I did not call attention to and that is that with 10 pounds to 50 gallons of water, it controlled the scale just as well as it did at 16 pounds or at 32 pounds. In other words, it would seem that when combined with barium the sulphur is somewhat more effective than when combined with lime, or rather, that much less sulphur is effective when combined with barium than when combined with lime, which, if this proves true, would make the barium product cheaper than the lime-sulphur solution.

A MEMBER: I would like to ask if this is in the form of crystals that can be reduced to dry powder?

MR. W. M. SCOTT: The formula is BaS_4H_2O, but it can be ground to a powder.

MR. R. L. WEBSTER: I would like to ask in regard to destroying the eggs of the oyster-shell scale, how did you determine that the eggs were killed?

MR. W. M. SCOTT: I did not intend to say that it killed the eggs of the oyster-shell scale. What I intended to say was that it appar-

ently prevented some of the eggs from hatching. Practically all of the eggs on the unsprayed branches hatched while 10 per cent or more of those on the sprayed branches failed to hatch and dried out. Barium-sulphide is fully as caustic and objectionable as lime-sulphur; so far as we have been able to determine, it keeps indefinitely; that is, we have had it for more than a year and it has not decomposed yet. Upon long exposure open to the air, it will gradually oxidize and a fine powdery substance accumulates on the outside of the crystals which amounts to a very small percentage after standing for more than four or five months.

MR. T. B. SYMONS: I presume it would have about the same effect on leaf curl as lime-sulphur.

MR. W. M. SCOTT: The fact that it has done everything that lime-sulphur has done in all of the experiments would lead us to believe that it would act about the same on leaf curl, although we have not had an opportunity to try it on that disease. We sent some to California and Mr. Foster made some experiments on lemon trees for red spider and other mites, comparing it with lime-sulphur solution. He obtained something like 98 per cent efficiency in controlling the citrus red spider and there was no injury to the foliage, while lime-sulphur solution applied at the same time scorched the foliage. It looks as though there is a promising field for this material in citrus spraying.

MR. P. J. PARROTT: In regard to the fungicidal properties of barium-sulphide, I will say that we used it in solution last spring with satisfactory results to control apple scab.

PRESIDENT H. T. FERNALD: The next paper will be read by J. W. McColloch.

RECENT RESULTS IN THE USE OF DUST SPRAYS FOR CONTROLLING THE CORN-EAR WORM

By JAMES W. McCOLLOCH, *Assistant Entomologist, Kansas Agricultural Experiment Station*

The corn-ear worm (*Heliothis obsoleta* Fab.) has long been recognized as one of the most difficult of the staple crop pests to control. A study of its life economy shows that there are a number of factors in the life cycle of this insect that are prohibitive of complete control and that the best that can be hoped for is a material reduction in the amount of injury: first, the larvæ feed almost entirely within the curl of the corn plant or within the ear where they are inaccessible to parasitic enemies and where as yet it is impossible to reach them with a spray; second, the larvæ are able to feed and develop on a wide

range of host plants; third, the adult moths are strong fliers and are able to travel readily from one field to another; and, fourth, the females are capable of depositing from five hundred to two thousand eggs, the eggs being laid singly and generally only one on a plant.

Numerous measures for the control of this pest have been advocated from time to time and some of them have proved effective in reducing the amount of injury. While the greater part of these measures are cultural in nature and aim at the prevention of the injury by the destruction of the insect before it infests the plant, a few of the measures advocated are remedial ones and are directed at the destruction of the insect after it infests the plant. Probably the most generally recommended remedial measure is that of poisoning. As early as 1879 Professor Comstock recommended the use of Paris green, either with water or dry with flour, as a means of destroying this insect on cotton.

Spraying as a measure of controlling the corn-ear worm on corn not only has received much prominence during the last few years but also seems to be growing in favor, and from a number of different sources good results have been reported in regard to its effectiveness.

Six years ago the Department of Entomology of the Kansas Agricultural Experiment Station took up a study of this method and since then the work has been carried on more extensively each year. It was found that a large percentage of eggs deposited during the summer were placed on the fresh corn silks and that the worms causing the injury to the ear originated from these eggs. The young larvæ on hatching from the eggs begin feeding on the silks and eating their way down into the ear. From the data thus accumulated it seemed possible to control a larger percentage of the injury by keeping the silks sprayed during the silking period.

As a preliminary to certain general spraying experiments some work was done to determine what poison could be used most effectively against the corn-ear worm and at the same time not be injurious to the silks. From the results of this work it was found that powdered arsenate of lead was the most efficient poison.

During the past six years in Kansas the average number of ears of corn injured by the corn-ear worm ranged from 85 to 95 per cent and from 5 to 25 per cent of the grains on these ears have been injured, either by the worm or by the accompanying moulds and fungi. Much of this injury has been so severe as to render the corn unfit for feed or for seed or show purposes.

During the past summer the department of entomology, in coöperation with the Union Sulphur Company, carried on a series of dusting experiments. Three plots, each one-third acre in extent, were dusted

with different strengths of Corona dry arsenate of lead. The silks in Plot 1 were dusted with 100 per cent arsenate of lead, those in Plot 2 with 63 per cent arsenate of lead, and those in Plot 3 with 50 per cent arsenate of lead. Sulphur was used as a carrier of the lead in Plots 2 and 3. A fourth plot was kept for a check. The dust which was applied by shaking from an ordinary cheese-cloth bag was applied every three days during the time the silks were fresh. No attempt was made to get the poison on any other part of the plant. Owing to the dry weather the applications were made more frequently than would ordinarily be necessary. The results of this experiment are shown in the table.

TABLE SHOWING THE RESULTS OF DUSTING CORN TO CONTROL EAR-WORM INJURY

Plot	Treatment	Cost			Per Cent Ears Injured	Per Cent Grain Injury	Amount Mould Injury	Yield
		Poison	Labor	Total				
1....	100% A. of L.	$3.36	$1.76	$5.12	63	Less than 1%	None	10.7 bu.
2....	63% A. of L.	1.82	1.61	3.43	66	Less than 1%	None	12.6 "
3....	50% A. of L.	2.20	1.70	3.90	88	About 5%	Moderate	12.5 "
4....	Check				98	About 10%	Bad	11.9 "

While over 60 per cent of the ears in Plots 1 and 2 were injured by worms the damage was so slight as to be almost negligible. In almost every case only one or two grains were injured on each ear and the usual moulds and fungi which accompany corn-ear worm work were not present. In the check plot the injury due to the ear-worm and to the accompanying moulds and fungi was so bad that much of the corn was unfit for feeding to stock, especially to horses.

The results of the past summer show that the 63 per cent mixture controlled the corn-ear worm practically as well as did the pure arsenate of lead. The difference in cost, however, was about $5.00 less per acre in favor of the 63 per cent arsenate of lead.

From the results given in the table it is seen that the cost of this treatment is prohibitive where corn is grown for forage and grain purposes. It is the opinion of the author that this cost can be reduced fully one-half by lengthening the period between applications to five days and by using a cheaper carrier, such as hydrated lime. This, however, would still make the cost at least $5.00 per acre. Where corn is raised for show purposes or for seed and roasting ears, dusting can be recommended as being very profitable. Sweet corn can be sold on the market for from five to ten cents more per dozen ears when it is known to be free from ear-worm injury.

The following conclusions may be drawn from the results thus far obtained:

(1) The amount of corn-earn worm injury can be greatly reduced by the thorough dusting of the silks.

(2) The cost of this treatment is prohibitive where corn is raised for grain and forage purposes.

(3) This treatment is profitable where corn is grown for roasting ears, show purposes or for seed.

(4) Sixty-three per cent arsenate of lead is equally as effective as pure arsenate of lead and costs less.

PRESIDENT H. T. FERNALD: The next paper will be by Leonard Haseman.

THE CORN-EAR WORM

By L. HASEMAN, *Columbia, Mo.*

During the past few years this pest has been unusually abundant in Missouri and has done an enormous amount of damage to corn and other crops. Mild winters with dry summers followed by early fall rains seem to provide the most favorable conditions for this pest. Our records of the past three years seem to prove this. This pest has been on the increase for the three years just past and since the generally recommended precautions and remedies have given little relief, an attempt is being made to study the life and habits of the insect more carefully in hopes that some treatment may be devised which will prove more effective in controlling this pest. The work is scarcely begun so these remarks will be confined to those facts which we have been able to work out during the past year.

FOOD PLANTS.—Corn is clearly the favorite food of this pest, though it feeds readily on other plants and plant parts. Early in the season the caterpillar works down in the growing tip of the corn. Its work in the ears begins at "shooting" time and may continue until the grains are dry and hard. Green tomatoes are also badly attacked, especially in the fall. Cotton where it is grown is also a favorite food, the caterpillars boring into the bolls and feeding on the seeds and fiber. The caterpillars are also destructive to beans, peas, cowpeas and other legumes which develop pods. Late in the fall they may attack the succulent growth on alfalfa, clover and other plants. They feed largely as borers though they may feed exposed on the foliage and tips of plants. They are very voracious when hungry, often feeding on each other or other species of caterpillars. They are, therefore,

100% Powdered Lead Arsenate

63% Powdered Lead Arsenate

50% Powdered Lead Arsenate

Check—No treatment
Piles on left show uninjured ears, piles on right injured ears

quite general feeders, especially late in the fall when they are not confined to cornfields by any means, which makes it impossible to reach them with winter plowing.

LIFE HISTORY.—The number of broods a year in Missouri has not been carefully worked out if in fact there is a definite number. It is a question as to just how many broods occur before the ears form. After the ears form the broods so overlap that it is difficult to differentiate them, though from our breeding records it is evident that there are a number of broods a year.

Egg.—The female ovaries contain as many as 1000 eggs in all stages of development. It is not likely that all are matured and deposited, though judging from the number of eggs found on the silks of one ear this is not unbelievable. Egg laying must last several days. Eggs are invariably placed on the corn silks the first night they are out. In some cases 70 eggs have been found on the silks of a single ear. Most of the eggs are stuck to the silks though some are deposited on the shucks.

Caterpillar.—The eggs hatch in about three days on an average, so that the worms are at work on the silks almost as soon as pollenization has been completed. At first the caterpillars are too small for the average eye to detect them readily. They feed at first on the fleshy silks and as they increase in size, follow the silks down to the grains and feed on them. Later other eggs are deposited on the tips of ears so that small and large worms are found in the same ear. In some cases one caterpillar may form a tunnel almost the full length of the ear, though more often it destroys all the grains at the tip.

The average length of the larval period is 18½ days and has been found to vary from 16 to 21 days.

Pupa.—Pupation occurs in the soil or rarely under moist rubbish. The depth to which the caterpillar bores before pupating varies. In breeding jars with from one to three inches of sand or soil they bore to the bottom invariably.

The pupal period in the fall varies from 7 to 18 days with an average of 14 days.

Adult.—The moth is very active and feeds on nectar of flowers and juices of fruits. It flies and feeds during the day as well as at night. This is especially true on cloudy days. The eggs are not all matured at the same time and evidently the food taken is used in maturing the eggs during the egg-laying period.

The length of the life of the adult moth was not determined except in case of moths reared and confined in breeding cages. Under those conditions the moths soon die, the average life being 5 days. In nature the life period of the moth is evidently much longer. This must be determined.

EXTENT OF INJURY.—During the past summer and fall 75 to 80 per cent of field corn grown in bottom land which had been in corn last year and winter plowed was attacked by this pest. The extent of this injury to each ear varies but the total loss is at least 10 per cent of the crop. In case of fall grown sweet corn 100 per cent of the ears were attacked with practically a complete loss of the crop. With such damage as this the total loss throughout the corn belt amounts to several millions of dollars.

The actual damage does not stop with the corn which is consumed but fungus growths of the smut type follow up the work of the worm and destroy much more of the corn. Some of these smuts seem to have poisonous properties and some veterinarians attribute the poisoning of stock fed on wormy corn to these smuts. If this is true the pest is indirectly responsible for such losses. In the past three years a great many animals have been lost due to poisoning in this state.

EXPERIMENT FOR PREVENTING INJURY.—Since it is not possible to reach the pest successfully with remedies generally recommended and since coöperation of farmers is not possible, an attempt has been made to find some treatment of corn which will protect the crop during the growing season. The pest being one which feeds first on the silk and later enters the ears, it was thought that some treatment of the ears at "shooting" time might accomplish this.

We have used a number of materials both in the form of a spray and as a dust. It is necessary that the material used must not injure the silks or ears and if it is to give results it must either poison the young worms or repel the moth or worms. The repellents used have given no results so far. The poisons in some cases injured the corn, in other cases gave no results, while in case of powdered arsenate of lead the damage was reduced from 75 to 35 per cent.

This work is to be continued along those lines which have proven most successful. This year we used 5 acres of field corn and one-fourth acre of sweet corn in our experiments. While at present the results seem rather discouraging I believe an economical treatment can be found that will save the corn crop.

MR. WILMON NEWELL: I would like to ask Mr. McColloch whether he made any observations on the feeding of the larvæ on the silks before they made their way inside the shuck.

MR. J. W. MCCOLLOCH: They may feed for a few hours after hatching. They feed on the egg shell first and then start down into the ear. We have not carried on very much work along that line but they move pretty rapidly to the ear and probably within six hours after they hatch they are down in the tip of the ear.

MR. T. J. HEADLEE: I think Mr. Richardson can tell us something about this.

MR. C. H. RICHARDSON: Experiments were made summer before last in which we found that the young worm was in the apex of the ear within twenty minutes after hatching. These were laboratory experiments. I was not able to prove this in the field as the difficulties of observation were many. There was very little feeding until the worms were within the apex of the ear well hidden in the silk. I think the efficiency depends on a little of the insecticide deposited on the silks sifting downward as the silks grow out.

A MEMBER: I would like to ask if good results have been obtained with hydrated lime, as we found it was very difficult to prevent a separation of the arsenate of lead and the hydrated lime.

MR. J. W. MCCOLLOCH: As far as I know hydrated lime has not been used very extensively. The chemical company with which we coöperated this year suggested its use in the place of sulphur.

MR. T. J. HEADLEE: At one time we collected a little evidence on the use of lime as a diluent for powdered arsenate of lead. Generally speaking these tests showed no injury. In some cases, however, the collection of the lime and lead at the axils resulted in the bleaching of the leaf at that point. This was not, however, the universal rule, indicating that the constitution of the lime was variable. As a matter of fact, it is extremely probable that the air-slaked lime used was not yet entirely changed and that the bleaching occurred when the lime was still caustic. The physical nature of lime seems well adapted to serve as a diluent for the powdered lead, but its caustic nature must be changed.

I should like to ask a question on my own account. I should like to inquire whether Mr. Haseman or Mr. McColloch have made use of a mechanical distributer of the poisons, and what results they have gotten, if any.

MR. HASEMAN: Would simply say that our machine will powder off—a thin dust.

MR. MCCOLLOCH: We used an ordinary cheesecloth bag.

MR. HEADLEE: I asked that question because in the summer of 1913, Mr. Richardson of our department made a thorough test of a horse machine. This distributer was devised by the late Mr. Karl R. Wundt and the speaker and built by the Dust Sprayer Manufacturing Company of Kansas City, Mo. The mixture was delivered as dust under pressure and gave the whole corn plant, especially the ear, a fine coating of the poison. It was tried in Missouri by Mr. Wundt in the summer of 1912 with excellent results. In our test it failed to effect control. A careful study showed that it failed because the young

worm in most cases penetrated the silk below the poison before attempting to feed. The maintenance of the small pile of dust placed on the silks in course of hand application caused the poison to filter down between the silks as they grew and kept the very zone in which feeding began poisoned. In this way the hand applied poisons effected satisfactory control while the machine applications failed.

MR. F. C. BISHOPP: Mr. McColloch is to be congratulated. The control of the boll worm is certainly rather difficult in the case of corn. It seems apparent that they do not have the worm as badly in these two states, Kansas and Missouri, as we had farther south. In Texas for instance, almost 100 per cent of the ears are infested in certain localities. The number of worms is apparently much greater. There we have found that often corn ears are infested by larvæ which hatch from eggs deposited on the husks or somewhere else than on the silk, within one day or less after the silk begins to put out. You would have to begin your poisoning the minute the ear begins to show silk. Another point, I fear we will experience much difficulty in getting this poisoning system established in many of the corn-growing regions. While it may be practical on a rather small scale, it is doubtful if the same method will be generally applicable.

MR. LEONARD HASEMAN: We also get worms in every ear of late corn so that not merely 70 or 80 per cent but 100 per cent injury occurs in the case of late maturing corn.

I would like to ask Mr. McColloch if he has used poisoned bait for the moths; and also if he notes any difference in the work of the pest on ears which have been opened slightly just at "shooting" time? We seem to find that if we open the ears slightly at the tip, we have less worms than where they are untouched.

MR. J. W. MCCOLLOCH: We tried the poisoned baits on moths and also attempted to catch them in fly traps, but the results were practically negative.

MR. T. B. SYMONS: I would like to ask Mr. McColloch as to diluting arsenate of lead?

MR. J. W. MCCOLLOCH: Sixty-three per cent arsenate of lead contains 63 parts of arsenate of lead and 37 parts of sulphur.

PRESIDENT H. T. FERNALD: I would like to say as a matter of record in addition that during the twenty-eight years that the Experiment Station in Massachusetts has had an Entomological Department, four cases, I believe, of the occurrence of the corn earn worm have been recorded, all of these from the extreme southern or southeastern portion of the state, from the territory that I have in my address alluded to as rather typically southern in its nature.

PRESIDENT H. T. FERNALD: The next paper will be read by Mr. George A. Dean.

FURTHER DATA ON POISONED BRAN MASH FLAVORED WITH FRUIT JUICE AS A MEANS OF CONTROLLING SOME INSECTS

By GEO. A. DEAN, *Entomologist of the Kansas Agricultural Experiment Station*

GRASSHOPPERS

Last year the writer read a paper before this association describing how the grasshopper outbreak in Western Kansas was successfully controlled by distributing over the infested areas poisoned bran mash flavored with either orange or lemon juice. In that paper it was stated that almost one thousand tons of poisoned bran mash were distributed in twelve counties, totaling an area of twelve thousand square miles and that from 60 to 80 per cent of the grasshoppers were killed by the one application. In the discussion that followed the writer further stated that the adverse conditions produced by the dry, hot weather probably played a considerable part in the unusual results accomplished. However, during the past season the same poisoned bait was thoroughly tested in several localities where the climatic conditions were entirely different from those of Western Kansas and the reports from these districts are equally as good as those had in Kansas. In an editorial of the August number of the JOURNAL OF ECONOMIC ENTOMOLOGY we find the following statement relative to the use of the bait in New York: "A localized though widespread outbreak of the redlegged grasshopper and several associated forms was quickly handled in threatened grain fields by the use of the Kansas bait, brought to notice only last year. Dying insects were to be seen within four hours after the distribution of the bait and within three days about four-fifths of the grasshoppers in a field were dead." A letter of November 12, 1914, from Mr. Arthur Gibson, chief assistant entomologist of the Dominion of Canada, states: "You will be interested to know that we had excellent results with the Kansas formula flavored with lemons in Ontario and Quebec provinces. Near Ottawa counts made diagonally across fields of oats, etc., gave 50 to 414 dead locusts to the square yard. The cost was 25 cents per acre including labor. In Quebec province the application of the mixture was even more remarkable, the results being from 900 to 1,200 dead insects to the square yard. The cost was 18 cents per acre exclusive of labor."

This year in Kansas the poisoned bait was used under entirely different conditions than those of the summer of 1913. There was no general outbreak of grasshoppers but there were several local infestations in the central and even in the eastern parts of the state, and during the late summer and early fall the grasshoppers were in sufficient numbers

to seriously threaten the new alfalfa and the new wheat. They came into these crops from adjoining fields, pastures and roadsides, and had the farmers not been prompt in the distribution of the bran mash the grasshoppers would have seriously injured the crops. The farmers were in close touch with the situation and just as soon as the grasshoppers moved into the edge of the alfalfa or new wheat, a strip of the poisoned bran mash was scattered broadcast early in the morning along the edge of the crop into which they were moving. If they had already spread into the fields the bran mash was sown over the infested portions. It was scattered in such a manner as to cover about five acres with the amount of bait prepared by beginning with twenty pounds of bran. Inasmuch as the grasshoppers kept coming into the alfalfa and wheat from adjoining fields, it was necessary in several cases to make a second and even a third application of the bait at intervals of from three to four days. In practically all cases where the bran mash was used the farmers were successful in destroying the grasshoppers.

Army Worms

The past season was an unusual one in Kansas for serious outbreaks of insects, consequently there were several opportunities to thoroughly test the value of poisoned bran mash for the control of insects other than grasshoppers. One of the first insects to appear was the army worm (*Leucania unipuncta*). It appeared in devastating armies in many localities over a large portion of the eastern half of the state. In some instances from ten to fifteen acres of corn and several acres of garden crops were completely destroyed in a single night. Alfalfa fields of from ten to one hundred acres were soon devastated. Fortunately, the army worms were discovered early enough in the season to give a few days to prepare to meet them. Eight or ten days before the farmers were aware of the danger threatening them, the army worms were discovered in corn fields that previously had been in rye. In fields of this sort the dust barrier was impracticable because the worms were distributed all through the field. Poisoned bran mash flavored with oranges was at once sown broadcast. Within two hours the worms were dying and the next day from 90 to 95 per cent of them were dead. In other fields where the worms had already destroyed the corn and were moving into nearby corn fields or into garden crops, it was impossible to check them by means of a dust barrier or a ditch because of rainy weather. A strip of bran mash was sown just in advance of the worms. So effective was the bait that the corn and garden crops on the other side of the strip were unmolested.[1]

[1] It should be stated that while several of the experiments were being conducted the army worms were feeding and moving during the day. It was cloudy and slight rain was falling part of the time.

On finding the poisoned bran mash practically one hundred per cent effective, not only under different climatic conditions but also with the worms infesting different crops and moving in different manners, the writer felt safe in recommending it as the most practical and effective method of controlling the army worm. No time was left for further experiments. The department, through the county demonstration agents and its special reporters, was in close touch with the situation over the state. On May 30 the general warning was sent out by wire and by letters calling attention to the seriousness of the infestation and urging immediate action. The next day the daily papers gave wide publicity to the serious outbreak and recommended the use of the bran mash, the dust barrier, and spraying with an arsenical spray. Within two days several of the county agents through the bankers' associations and county clubs and by the use of the rural telephones had their counties not only organized but had the farmers already distributing the bran mash. In nearly all cases the farmers were prompt in organizing and putting into operation the methods of control recommended. If the worms were moving into an adjoining field a strip of the bran mash was sown broadcast along the edge of the field into which they were moving. If they were already in a field of corn and the corn was small, the bait was sown broadcast down in the lister furrows. If the corn was larger, it was scattered so that a small portion of the mash dropped in the curl. If they were abundant in an alfalfa field the crop was cut at once and the worms destroyed as they were moving into an adjoining field. If they were working on alfalfa that was just starting up after it had been cut, the bait was sown broadcast over the infested field. Instructions were given to scatter the bran mash in the evening unless the worms were working or moving during the day, which they did on cloudy and slightly rainy days.

In nearly all cases the results were excellent. Many of the reports from the county farm agents stated that large numbers of the worms were dead within thirty minutes after the poisoned bait was applied and within two hours the majority were killed. One of the men of the department stated that in one case the army worms were coming into a corn field from an adjoining field of rye. To reach the corn they had to pass through an osage orange fence and during the day they congregated along the hedge in large numbers, and undoubtedly would have moved into the corn at night. Since there were hundreds of worms to the square yard along this fence it was an ideal place to distribute the bait. A heavy sowing was made just before noon under the hedge and along the rye field. Within thirty minutes hundreds of dead worms were found. Within two hours the ground was covered with dead ones and practically every small depression was filled with

them. Counts made in average places along the hedge showed over two hundred dead worms per square foot.

Such excellent coöperation was had from nearly all the farmers, and so well organized were many of the counties—credit for which should be given to the county farm agents—that within less than two weeks the army worm infestation was completely under control and instead of a loss of some five or six million dollars to agricultural crops (which would be a conservative estimate of the damage if the worms had not been destroyed, and a loss that actually did take place in an adjoining state) the damage in Kansas was considerably less than a million dollars.

Variegated Cutworm

It is nothing unusual in Kansas for the variegated cutworm (*Peridroma saucia*) to appear in great numbers in local districts and take on the habits of the army worm. In the spring of 1909 the infestation of this insect, which was more severe than usual, extended over several counties in the south central part of the state. At that time they appeared in the early spring and destroyed thousands of acres of wheat and many acres of alfalfa. The writer as well as two other men of the Experiment Station spent several days in the field endeavoring to find an effective method of control. The ordinary poisoned bran mash did not prove effective and was soon discarded as an ineffective and an impracticable method of control.

The infestation of last spring was a much wider one, extending over almost the same territory as that infested by the army worm. In fact, in many cases the army worms were associated with the cutworms in the alfalfa fields. Instead of injuring crops early in the season and confining their attack almost entirely to wheat as they did in the previous infestations, they appeared almost sixty days later or about the first of June, and the main injury was confined to the alfalfa, although in a few cases after the alfalfa had been cut, they migrated into garden truck and corn.

The first crop of alfalfa was cut during the last of May and the first week in June. If army worms were present they at once moved into the adjoining fields of corn, wheat, or garden truck, but in nearly all cases the cutworms remained in the alfalfa. Climatic conditions were very favorable for a rapid growth of the second crop, which was sufficient to hold the cutworms, although apparently it did not entirely satisfy their appetites. Within two or three days the farmers noticed that the alfalfa was not growing and that the ground was just as bare as the day the alfalfa was cut. An examination of the fields soon showed that the worms were eating the new growth of alfalfa just as soon as it appeared. Although the worms did not get enough to sat-

isfy their hunger during the night, they did get enough to eat to keep them from migrating, and with the advent of day they entered the ground to wait for the next night's meal. This made conditions ideal for poisoning them. In the evening the bran mash flavored with oranges or lemons was sown broadcast over the infested fields. It was sown in such a manner that the amount of bait prepared by beginning with twenty pounds of bran covered about five acres. In nearly all cases the results were practically one hundred per cent effective. One application was sufficient. In some cases the morning after the application of the bran mash from one hundred to five hundred dead worms were found per square yard. In fact, one could scarcely believe so many worms were present until he saw the enormous number of dead ones the next morning.

The Black Cricket

In many parts of Kansas last summer there appeared an unusually large number of black crickets of which the most common species was *Gryllus pennsylvanicus*. The crickets, attracted to the lights, soon found their way into dwelling houses, warehouses, and stores of all sorts. In houses they concealed themselves during the day under heavy pieces of furniture and in closets. Frequently they were found in large numbers in the basement. Seemingly they sought the basement not only to find suitable hiding places but also to get away from the heat. In the dwelling houses and dry goods stores they cut curtains, clothing, and fabrics. In two instances at Manhattan they seriously injured rubber goods stored in the basement.

After a few experiments it was found that the most practical and effective method of destroying them was to distribute poisoned bran mash prepared in the following manner:

Bran	1 lb.
Paris green	1 oz.
Syrup	3 oz.
Orange or lemon	¼ of a fruit
Water	1½ pts.

Here, again, the bait when flavored with orange or lemon seemed not only more attractive but also more appetizing and thus was readily eaten by the crickets. Small amounts of the bran mash were put in shallow pans or dishes and placed in the closets, behind and under heavy pieces of furniture, in the basement or any place frequented by the crickets. In the basement the bait was also placed in teaspoonful lots in the corners, behind boxes and other hiding places. The crickets, like the grasshoppers, do not eat the poisoned mash so readily when it is dry, thus it should be distributed in the evening because the crickets work mostly at night.

MR. W. E. BRITTON: I would like to ask Mr. Dean if he tried this on cutworms?

MR. GEORGE A. DEAN: The variegated cutworm, the outbreak of which was discussed in my paper, is also one of the common garden cutworms. Although we have not tried this poisoned bran mash for the control of cutworms in gardens, we have tried the other bran mash (not flavored with fruit juice) and it proved fairly effective. Since the bran mash proved so effective in the control of the variegated cutworm in the alfalfa fields, I can think of no reasons why it would not also be effective in destroying the cutworms in gardens.

MR. E. O. G. KELLY: I would like to ask if the insects prefer the poisoned bran over the crop they are attacking?

MR. GEORGE A. DEAN: Yes, in many of our experiments we have found this to be true. I am sorry I neglected to bring the slides, which I had intended to bring and which would have illustrated this very distinctly. For instance, on one side of the bran mash barrier the rows of corn, about eighty rods long, and at that time the plants about fifteen inches high, stand absolutely uninjured, while on the other side of the barrier the corn is completely taken. In the case of grasshoppers we have found that they would leave the alfalfa and take the bran. In the case of army worms in alfalfa, as stated in my paper, we recommended the cutting of the alfalfa and then poison the worms as they migrate. In most of our work the alfalfa was either ready to cut or had been cut. Personally, I would not advise the scattering of it in alfalfa fields where the crop o" plants are large. First cut the alfalfa and then distribute the bran mash.

MR. WILMON NEWELL: In Texas we have used this mixture extensively the past year in the case of local grasshopper outbreaks and the results have been uniformly satisfactory. In one case we distributed the poisoned bran mash in a field of green oats that were just heading. The grasshoppers preferred it to the green oats and the crop of oat hay was saved. It was impossible to cut the oats and apply the mash afterwards for the weather was too wet. Its use in this case saved the entire crop.

MR. H. A. SURFACE: Any effects of poisoning native birds or domestic animals from its use?

MR. GEORGE A. DEAN: I will state that in all of our distributing of the poisoned bran mash we have yet to hear of any authentic case of poisoning any barnyard fowl or domestic animal in any way, shape or manner. We have noticed bees about it, but in no case have we found them dying. No birds have been killed. Professor Dyche, of the Kansas University, who is Fish and Game Warden of Kansas, with headquarters in the part of the state where the bran mash was

distributed last year in the control of grasshoppers, has to my knowledge, found no instance of it killing birds. Of course, if it were placed out in handful lots, as was formerly recommended, there probably would be no question about it killing birds, but when the mash is distributed in such a manner that twenty pounds will cover five acres, there is absolutely no danger. We have had chickens, turkeys, and hogs following right after us while sowing it in alfalfa fields. They do not get enough to harm them.

MR. W. C. O'KANE: If army worms are feeding in corn say two or three feet high, of course during the daytime they are often curled up in what is left of the leaves of the corn. Suppose you have six or eight or ten army worms per stalk of corn, as I think we had, and they were down in these unfolding leaves, would it be necessary either to get the poisoned bran mash down into these leaves or to get some on the stem or stalk of the corn?

MR. GEORGE A. DEAN: In most of our work the corn was not nearly so high as you mention in your case. If the corn were fairly large we tried to sow the bran mash so that some of it not only fell down in the curl, but also lodged on the blades, and in many cases the worms ceased at once to eat the corn and ate the bran mash. We also noticed in many cases that where the bran mash was scattered along the base of the plant they would leave the corn and eat the poisoned bait. This corn was not very high. If the corn were large and you could not get the particles of bran mash on it conveniently, I would sow it on the ground along the row so that they would find it when they moved on to another plant.

MR. E. P. FELT: Do you consider it safe to sow the poisoned bran mash in fairly liberal quantities so that it will drop down in the leaves of the corn?

MR. GEORGE A. DEAN: I have no data on this at all. I simply know that our corn was so small that there was absolutely no danger, and I believe this will be true in any case where the corn is not over two feet high. If the corn were large, say in the silk, there might be, in case the bran mash were sown rather liberally, some danger, if enough of it lodged down in behind the blades, of it proving harmful in case the corn were used for feed.

MR. W. S. REGAN: During the past summer we had a rather serious outbreak of the army worm in eastern Massachusetts. We used bran mash to kill the worms and we did hear of some cases where birds were killed by the bran mash. I know of one case where a farmer reported having found 11 blackbirds after he had scattered the bran mash over the fields; it also killed some of his chickens and turkeys. I did not see these.

MR. GEORGE A. DEAN: Did he scatter it as thin as twenty pounds to five acres?

MR. W. S. REGAN: Yes. He used only about ten pounds for a trial and this amount was scattered over an area of several acres according to his statement. I could hardly believe anything else could be responsible for it under the conditions.

MR. GEORGE A. DEAN: In our work we often receive reports of it killing chickens and turkeys. We have taken the trouble in several cases to investigate these reports but in no case have we found any evidence of arsenical poisoning. In several cases where the fowls were dead, death seemingly was due to eating too many of the hoppers. The hind legs of the hoppers had caused a stoppage and apparently death was due to inflammation. It is nothing uncommon to lose a number of young turkeys if they are allowed to gorge themselves on grasshoppers. A young turkey, like some other animals, when it finds something good to eat hasn't any more sense than to eat too much. If barnyard fowls are obliged to run down the grasshoppers they are not so apt to gorge themselves, but if they find large numbers of dying grasshoppers in under trees or in shady places they are very apt to overload in feeding on them. As stated before, if a person uses a little judgment in the distribution of the bran mash, there is no danger of it injuring birds or barnyard fowls. I might state that Kansas stands very high in the number of species of birds, and after distributing almost a thousand tons of bran mash, as we did in the summer of 1913, it would seem that if birds were eating a sufficient amount of the bran mash to kill them, we would have at least a few cases to report.

PRESIDENT H. T. FERNALD: The State Ornithologist of Massachusetts looked into some reported cases in Massachusetts and was satisfied that the birds were killed by eating the mash—though how thoroughly he investigated I cannot say.

MR. E. G. TITUS: A few years ago we had occasion to take up the question of chickens dying in an orchard where poisoned bran mash had been used. On opening their stomachs, none of the bran mash was found, but in every case they were filled with grasshoppers, and it appeared that they had died by being choked with excessive numbers of these insects. We also found on examination that no injury resulted to sparrows in sections where the poisoned mash was used.

A MEMBER: I would like to say that a careful observer in Michigan reports that birds will not touch poisoned bran if orange or lemon juice is used in it.

MR. W. S. REGAN: We had very good success with barriers to prevent the migration of the army worm caterpillars. First, the plowed furrow retarded their advance. Powdered air-slaked lime dusted

heavily along the furrow aided materially in checking them. We noticed that the caterpillars were not inclined to pass through the lime, turning about and getting out of it as soon as they came in contact with it. Poisoned bran mash scattered along the furrow killed practically every caterpillar. Ordinary road oil also proved an effective barrier. It was applied with a garden watering-can, the spraying top of which had been removed, making a strip a couple of inches wide about the field to be protected.

MR. T. J. HEADLEE: Three-fourths of the damage done last summer in New Jersey by army worms occurred in lawns. Generally over the state and especially along the shore, lawns were so eaten that they turned brown and seemed dead. Arsenate of lead (dry and wet) poisoned bran mash (without fruit juice) were used, with only partial success. Mr. W. B. Duryee, Jr., the farm demonstration agent in Monmouth County, devised a scheme which worked better than any other tried. Shallow ditches were dug along paved walks, walls and building foundations. Finely pulverized lime was dusted lightly over the infested lawns, taking care to keep the ditches free from it. The following morning the worms were found collected in the ditches and were destroyed by sprinkling them with gasoline. The gasoline was used instead of kerosene because it left no undesirable stain upon the walks, walls and foundations. In nearly all cases a single treatment proved sufficient to free the infested lawn from further trouble.

For general field crops and garden infestation barriers have again demonstrated their value over poisons. The trench 12 inches deep and 8 inches wide with 6–8 inch-deep post holes along its bottom at distances of from 10 to 20 feet was completely effective, the worms collecting in the holes and being destroyed by crushing or by sprinkling them with kerosene. It was also found that the ordinary oil treatment accorded to macadam roads when freshly applied rendered the road a complete barrier. Advantage of this discovery was taken to protect threatened truck fields.

PRESIDENT H. T. FERNALD: The next paper will be read by Mr. E. P. Felt.

GRASSHOPPER CONTROL IN NEW YORK STATE

By E. P. FELT, *Albany, N. Y.*

New York State suffered last summer from an almost unprecedented grasshopper outbreak, the injury being confined largely to the sandy areas bordering the Adirondacks and extending from Poland, Herkimer County, through Fulton and Saratoga counties north to Warren and Clinton counties. *Melanoplus atlanis* Riley was the principal

offender, though *Melanoplus femoratus* Burm., *Camnula pellucida* Scudd. and *Dissosteira carolina* Linn. were also present and in some localities rather abundant, this being particularly true of Camnula at Wells. The outbreak was a culmination of one or more years of grasshopper abundance which seemed to be greatly favored by unusually dry weather in May and June, while the pests were in immature stages. The limitation of the outbreak to sandy, especially wild or semiwild areas was very evident, and although there was some drifting of the grasshoppers with the wind from field to field, in general the pests were local in habit. Injury to buckwheat was quite characteristic in that the young grasshoppers invaded the fields from the grassy or bushy fence rows and destroyed all of the grain for a variable distance of one to three, and in some cases ten rods, the middle portion of the field being almost uninjured and comparatively free from the pests. A noteworthy feature was the abundance of grasshoppers in the cities of Gloversville, Saratoga and Glens Falls, in particular, especially the first named. There were times when the insects were so numerous that they were swept from the sidewalks and it was by no means uncommon to see 15 to 25 or more on a limited portion of the outside of a building or a fence. Complaints began to be received in early June and by the middle of July the outbreak was at its height.

Throughout the region there was a general feeling that it was comparatively useless for the individual to take up what seemed to be a very uneven conflict. With the above conditions in mind a large scale demonstration was started July 18 by the entomologist, in coöperation with agents of the State Department of Agriculture. The Kansas bait used so successfully elsewhere last year was employed and the mixture distributed over a badly and uniformly infested twenty-acre oat field, beginning about 10.30 in the morning, a good handful of the bait as sown covering approximately two hundred square feet. The distribution was so extended that one had to look closely in order to find the bait. Observations showed that many grasshoppers began to feed upon it within three or five minutes, and in some instances they seemed to drop from the oats, probably being attracted by the smell and gradually make their way to small particles of the mash. About four hours after the first application a few sick grasshoppers were observed here and there. At 6.30 the next afternoon, less than thirty-six hours after the beginning of the treatment, three-fourths of the grasshoppers in the field were dead or dying, 12 to 14 dead insects being easily found on a square foot and frequently six or seven were seen collected in small crevices as many inches long. Three days after the application it was estimated that about four-fifths of the grasshoppers were dead, 67 being found in one square foot and an

average square yard contained 26 dead grasshoppers, another one 64. Five days after the bait was distributed, sick grasshoppers were still to be seen, though there had been a heavy two-hour rain the day before and the efficiency of the mash was therefore probably decreased. The next day it was estimated that over .9 of all the grasshoppers originally in the field had been destroyed, and at the end of a ten-day period the fatalities approached 99 per cent. The cost of the materials was estimated at 13 cents per acre. Observations lead us to believe that the wider the distribution the more effective the results. This poison was not only tested in fields where grasshoppers were abundant and consequently had destroyed much of the more succulent vegetation, such as the new seeding and the younger leaves of the grain, but it was also used in several oat fields where there had been practically no injury and the new seeding was therefore thrifty and luscious. Even under such apparently adverse conditions, so far as efficiency of the poison is concerned, the insects freely ate the poisoned bait and succumbed before they were able to cause any material injury. The Criddle mixture was used by some farmers with almost equally good results though it is not nearly so easy to prepare. The experience of last summer also showed the advisability of protecting the nostrils with a moistened sponge and the avoiding of the poisoned dust so far as practical in the case of parties who are required to mix large quantities of the poison. There is a source of danger here which should be safeguarded against at the outset, otherwise serious results might follow.

We were unable to learn of any deleterious effects resulting from the use of this material when ordinary precautions were observed. The moist sweetened bran is very attractive to domestic animals and therefore great care should be exercised to prevent their gaining access to containers used for mixing or distributing the material. We distinctly advise against putting out the poison in small spoonfuls or masses, partly because there is greater danger of poisoning domestic animals, and also on account of the increased efficiency accompanying a sparse distribution. Under most conditions we would expect practical immunity from grasshopper injury following one application of the bait, even though the grasshoppers were allowed to remain unmolested in badly infested adjacent fields.

MR. S. J. HUNTER: Regarding the effects on the nostrils of the workers, it appears that Dr. Felt has found it about the same as we have in the west, where mixing such large quantities, our workers found it desirable to use gasoline propelled cement mixers. When issued,

however, to the farmers, the requisite amount of Paris Green was put in the center of each sack, and the farmer instructed to mix according to directions when he reached home.

PRESIDENT H. T. FERNALD: The next paper will be read by Mr. Wilmon Newell.

NOTES ON THE INSECT ENEMIES OF SUDAN GRASS

By WILMON NEWELL, *College Station, Texas*

As Sudan grass[1] has, through the publicity given it by the Bureau of Plant Industry, U. S. D. A., and the Texas Experiment Station, become a forage crop of much importance in Texas and the Southwest, mention of some of the insects attacking it may be considered timely.

The insect enemies of this crop thus far observed are not new to entomologists, but are comprised of insects which are already quite well known on account of their ravages on other crops.

THE SORGHUM MIDGE

First in importance is the sorghum midge, *Contarinia* (*Diplosis*) *sorghicola* Coq., on account of its destruction of the seed before maturity. This Cecidomyid is well known on account of its attacks on sorghum, milo maize and related crops, there being many localities in the South where the midge entirely prevents the maturing of seed. It attacks Sudan grass with equal facility and, while not injuring the crop so far as forage is concerned, it makes the production of seed well-nigh impossible in heavily infested sections. Inasmuch as the seed has thus far sold at prices varying from $1.00 to $1.50 per pound, the monetary loss is very considerable.

The sorghum midge is essentially an insect of humid sections and in localities of heavy annual rainfall, as in southern Louisiana and Mississippi and in the southeastern portion of Texas, it seems improbable that Sudan grass seed will ever be produced successfully.

In Texas the extent of damage appears to vary considerably with the seasons. The only portion of the state entirely exempt from the midge is the western part where the annual rainfall is usually less than 25 inches.

During the past two years Sudan grass has been grown, not only at the main Experiment Station at College Station, but also at each of the eleven sub-stations and this has given us a good general knowledge

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[1] *Andropogon sorghum*, var. Recently described by Prof. C. V. Piper, of the Bureau of Plant Industry, as variety *sudanensis*.

of the distribution and abundance of the insect. The following table shows the location of these stations, the annual rainfall and the estimated damage to the Sudan seed crop during the past two seasons:

RAINFALL AND INJURY TO SUDAN GRASS SEED

Station	Average Annual Rainfall		Estimated Damage to Seed Crop, Sudan Grass	
	Length of Record, Years	Inches	1913	1914
Angleton	18	49.54[1]	100%	95%[2]
Nacogdoches	7	45.44[3]	60%	100%
Troup	9	43.79	100%	100%
Beaumont	20	43.65[4]	20%	100%
College Station	24	37.87[4]	40%	95%[2]
Chilliecthe	8	33.64	None	None
Temple	28	33.36[4]	None	50%
Denton	1	33.14	15%	50%
Beeville	18	30.05[4]	None	50%
Lubbock	3	21.74	None	None
Spur	3	18.40	None	None
Pecos	4	7.93	None	None

[1] U. S. Weather Bureau record at Alvin, 20 miles from Angleton.
[2] A small seed crop produced very late in the season.
[3] U. S. Weather Bureau record at Lufkin, 15 miles from Nacogdoches.
[4] U. S. Weather Bureau record.

This table shows that localities having an average annual rainfall of 35 inches or more have experienced almost total destruction of the seed crop for the past two years, whereas localities with an average rainfall of about 25 inches or less have been exempt from damage. Between these two extremes, *i. e.*, in localities where the average rainfall is between 25 and 35 inches, the amount of damage has been highly variable.

Sufficient data are not yet at hand to permit of any positive correlation between local climatic conditions and the extent of midge injury. However, it appears in general that, the greater the precipitation during the spring and early summer months, the greater is the damage by the midge. This is indicated by the data following:

Spring and Summer Precipitation and Midge Injury

Station	1913		1914	
	Rainfall, May, June and July, Inches	Damage by Midge	Rainfall, May, June and July, Inches	Damage by Midge
Beaumont	9.66	20%	22.64	100%
College Station	4.02	40%	9.45	95%
Temple	5.02	None	18.02	50%
Denton	8.44	15%	4.77	50%
Beeville	5.45	None	12.62	50%

As pointed out by Dean,[1] the only remedial measures thus far evident consist in clean harvesting, the complete destruction of Johnson grass and possibly the fumigation of seed to kill the hibernating larvæ. Johnson grass is a favorite host plant of the midge, its seed heads afford protection to the midge larvæ and its early heading in the spring gives opportunity for a generation of midges to be produced in advance of the heading of cultivated crops.

Sudan grass, in the latitude of central Texas, would produce two and sometimes three, seed crops per season were it not for the midge, but in seasons of heavy infestation there only remains the possibility of securing a very late crop of seed at a time when the parasitism of the midge is high. Thus at both College Station and Angleton in 1914, a partial late crop of seed was secured, though earlier crops of the seed were entirely destroyed.

The Conchuela

Strangely enough, the area which is too dry for the sorghum midge is the one in which the conchuela, *Pentatoma ligata* Say, reaches its greatest abundance. While this plant-bug is a general feeder, attacking cotton, small grains, alfalfa, foliage of trees, garden vegetables, etc., it is particularly avaricious in its attack on all members of the sorghum family. In Loving County during the past season it even prevented, to a large extent, the seed production of Johnson grass. Thus far large areas of Sudan grass have not been grown in the localities where the conchuela is at present abundant, but, owing to its fondness for all other members of the sorghum family, there seems little doubt that it will prove to be a serious obstacle to the extended cultivation of Sudan grass in the semi-arid sections.

[1] Bul. 85, Part IV, p. 58, Bureau of Entomology.

One of our correspondents, Mr. A. S. Whitten, of Porterville, Texas, has observed these insects hibernating in piles of wood, weeds and trash generally. The method of hibernation would suggest, as remedial measures, the early deep plowing of infested fields and a thorough winter cleaning up and burning of all rubbish affording hibernating quarters for the insect. Morrill[1] also recommends the destruction of all mesquite trees in the vicinity of infested fields, as the mesquite is one of the favorite native host plants of the insect.

The Angoumois Grain Moth

The Angoumois grain moth, *Sitotroga cerealella* Oliv., readily infests the seed of Sudan grass both in the field and in storage. During September and October, 1914, the moths were noted in great abundance among the heads of the uncut grass at Robstown, Texas, as well as in the shocks of harvested grain awaiting threshing. During the warmer days of November, also, they were abundant around the bins in which the seed had been stored.

Fortunately, Sudan grass seed shows a high resistance to injury by carbon bisulphide. In experiments which we have made to determine whether its germinating power might be affected by heavy fumigation it was found that as much as 15 lbs. to the 1000 cubic feet of bisulphide, confined for 12 hours, did not affect germination. In some instances the fumigation even appeared to stimulate germination of the seed. The germination tests were made in seed testers, both immediately after the fumigation and again nine weeks later. The results of a few of these fumigations are given in the table below:

Germination of Sudan Grass Seed Fumigated with Carbon Bisulphide at Different Strengths

Date of Fumigation	Amount of CS_2 per 1000 Cubic Feet	Per Cent of Germination, Sept. 5–10	Per Cent of Germination, Nov. 16–20
Sept. 1–5	1 lb.	91	90
Sept. 1–5	3 lbs.	88	90
Sept. 1–5	5 lbs.	97	91
Sept. 1–5	8 lbs.	83	94
Sept. 1–5	10 lbs.	91	91
Sept. 1–5	15 lbs.	86	78
(Not fumigated)	Check No. 1	86	83
(Not fumigated)	Check No. 2	86	83

[1] Bul. 89, Bureau of Entomology.

Other Insects

Like other grasses and small grains, Sudan grass is subject to attack by grasshoppers, cutworms, army worms, grub worms, etc. It is also to be expected that the stored seed will be found subject to attack by the usual seed-infesting insects, such as the saw-toothed grain-beetle, the granary and rice weevils, etc., but instances of such infestation have not yet come to our attention.

President H. T. Fernald: The next paper will be presented by Mr. S. J. Hunter.

SOME ECONOMIC RESULTS OF THE YEAR

Bees and Poison Bran Mash; Army Worms; Intermittent Seasonal Spraying

By S. J. Hunter, *University of Kansas, Lawrence*

To economize time, it has seemed desirable to summarize some of the economic work of the year under the one general head, rather than to present the same in several papers.

In the conduct of any field campaign, objections to some feature, as every entomologist knows, are likely to be raised, and these objections, to secure the undivided support of all concerned, have to be met.

Objections regarding the danger to stock through the use of arsenical poisons are of common occurrence. Two years ago, during the extensive use of the poison bran mash against the native grasshoppers, the question was frequently asked as to what effect the poison would have on bees, when distributed through a large alfalfa field where bees from large apiaries were at work. Last summer, Professor Caesar, of Ontario, wrote me that similar inquiries came to him from Apiarists. Under date of July 24, last, Professor Caesar writes:

> The bee-keepers of Ontario are alarmed at the supposed danger to the bees which they believe attends the use of your remedy for grasshoppers. I have used this remedy this year and saw no bees feeding on it. It has given good satisfaction as a treatment for grasshoppers. I should, however, be very pleased if you would kindly let me hear, as soon as possible, whether bees have been poisoned by it to any extent in Kansas.
>
> Sincerely,
>
> (Signed) *L. Caesar.*

In order to satisfy ourselves even more fully on this subject, Mr. George H. Vansell, our Apiary inspector, undertook a series of experiments to determine whether the bees would feed at all on the poison bran mash; and if so, under what circumstances, and with what results.

First, to determine whether the bees would partake of the poison at all, small piles were placed on the running board of the hives. Here, the bees did not go out of their way to come to the piles, but those which ran against it, stopped and began to lap up the mixture quite greedily, sometimes starting off, to return to lap again. Such were retained, and all died within three hours.

A number of bees were confined in a bell-jar with this poison. After a time, the bees came down and sipped the mash contentedly; they would then fly to the top of the jar, to return again for more of the sweet mixture. All those confined in the bell-jar partook of the mash and died; but on the running board of the hive, only 15 of those that passed over it during an hour's observations stopped to taste it. When the bran mash was scattered about a few feet from the hive, not a single bee halted to taste the substance.

Second, the bran mash was distributed in a sweet-clover patch where bees were unusually abundant and not one was observed feeding, or in any way being drawn toward the mixture. It was also distributed freely among rotting peaches on the ground where bees were feeding in large numbers, with similar results.

Last year, the poison was placed around in small piles among apiaries of 38 stands of bees and the honey systematically, taken from the stands. This usually makes bees more active in feeding. Even under these conditions, but a single bee was observed feeding on the mash. These attempts at feeding the poison bran mash to the bees were repeated morning, noon and night, and no evidences were observed which would tend to show that there was any appreciable danger to the bees from the distribution of this poison.

Furthermore, against the insects for which this poison is used, it is most effective when scattered early in the morning or late in the evening. Before the working hours of the bees began, the poison would, then, be too dry for them to feed upon.

From this it would appear that when the poison mash confronts the bees, they will partake of it and perish; but, that the use of the mash in field work is not attended by danger to bees.

Another common inquiry is the effect of this poison upon chickens. One series of experiments carried on in a ten-acre truck patch, composed of onions, rhubarb, asparagus, sweet-potatoes and tomatoes, will serve as an answer. This plot, located in Gray county, near Cimmeron, attracted grasshoppers from all the adjoining fields. The poison bran mash was scattered over this patch two or three times every week, in order to kill the hoppers as fast as they came in. The owner likewise used his chickens, about 500 in number. These were distributed in coops over the whole garden every morning, and no chickens, whether large or small, were poisoned.

There seemed to be some evidence, however, to show that turkeys are likely to be poisoned; due, probably, to their habit of eating large quantities of the dead and dying poisoned grasshoppers.

Further experiments will be necessary before we can speak conclusively upon this point.

Army Worms

The past season there were a number of local outbreaks of Army worms. The most effective means found for their extermination was the liberal use of the bran mash poison, scattered in the evening. The worms will often leave garden vegetation for the poison, and in our experiments, they were frequently observed turning back in their course to get this poison.

By actual yard-square counts, one application, in some instances, destroyed 90 per cent. of the worms. Death usually ensued about one hour after the feeding had begun.

Intermittent Seasonal Spraying

Among our commercial orchardists, it is universally accepted that intelligent spraying is necessary to profitable returns. Among the smaller orchardists, however, the question frequently arises regarding the necessity for annual spraying. That is, sometimes there is a notion that in an orchard where injurious insects and plant diseases have been well controlled for some years, an intermission of one year's time succeeding such spraying would not permit such enemies of the apple to become sufficiently prevalent to materially affect the crop. Last season an unusually good opportunity was offered to secure a practical answer to this question. That is, to determine what beneficial effects, if any, would accrue to an orchard this year, from three years' proper spraying prior to the present one. In other words, to determine whether an orchard, successfully sprayed for three years, could be profitably permitted to go unsprayed this year.

The orchard selected was a ten-acre orchard of commercial varieties which had been successfully sprayed for the three years past. Last year, and the year before, this orchard showed less than 5 per cent injury due to injurious insects and plant diseases. In this ten-acre orchard this year, two representative trees for each of the following varieties were chosen: Ben Davis, Gano, Jonathan, Black Twig, Missouri Pippin, Wine Sap and Willow Twig. The set of the fruit on these trees compared very favorably with that of the three previous years. Monthly counts, beginning with the first week in each month of the months of June, July, August and September were made of the drops from these trees, to determine the cause of the fall of the apples.

This was the same system that had been followed for the three previous years. These apples were scored and tabulated under the various injurious insects and plant diseases common to the apple. Of the entire 26,244 collected throughout the entire season, there were 218, or 1.5 per cent sound apples. The remaining 98.5 per cent had been checked in their growth and development by an injurious insect or plant disease, or by the two combined. Of those which dropped prematurely, the small percentage of sound apples might have their fall attributed to the wind.

The accompanying table illustrates this work in detail.

SUMMARY OF APPLE COUNTS OF INTERMITTENT SEASONAL SPRAYING

	June 9 and 10	July 8 and 9	Aug. 4 and 5	Sept. 2 and 3	Per cent.
Codling moth	1,526	1,845	2,940	2,659	46.3
Codling moth and bitter rot		274	945	3,346	23.9
Codling moth, bitter rot and curculio		3	152	556	3.6
Codling moth and blotch		12	508	450	4.9
Codling moth and curculio		18	755	1,296	10.6
Codling moth, blotch and curculio			53	12	.34
Curculio	496	60	100	259	4.63
Curculio and bitter rot		8	55	5	.34
Blotch			15	307	1.64
Blotch and curculio			38	240	1.42
Railroad worm		5	30		.15
Bitter rot		13	16	11	.20
Scab		7	5		.04
Codling moth and railroad worm			13		.06
Sound apples		218	30	42	1.5
Thinning drop	6,833				
Codling moth and scab		47			.24
Codling moth, bitter rot and blotch				32	.12
Total	8,855	2,510	5,628	9,251	100%
Sum total			26,244		

The question naturally arises, "What of the marketable apples"? Referring back to the last year's record for these same varieties, the smallest average yield per tree was one and one-half barrels of sound marketable fruit, in size, two and one-half inches, or better. This year, from these same trees, the number of apples still remaining at picking time averaged thirty-five to the tree, most of which were below market size. Obviously, no count or tabulation of these would serve any purpose. The climatic conditions this year were better than the two previous years; the only features absent this year were spraying and cultivation.

The above condition represents the situation in this orchard at

picking time. The loss was greater than might reasonably have been expected. The orchard is remote from any unsprayed orchard and the ground was left last season practically free from apples.

The conclusion, naturally, is that the orchardist can no more reasonably expect an apple crop without intelligent cultivation and spraying than can the farmer expect a corn crop without proper and intelligent planting and cultivation.

PRESIDENT H. T. FERNALD: The next paper will be read by Mr. H. A. Surface.

EFFICIENCY OF PARASITES OF THE SAN JOSÉ SCALE

By H. A. SURFACE, *Harrisburg, Pa.*

(*Withdrawn for publication elsewhere*)

MR. FRANCIS WINDLE: Through my inspections several years ago I noticed the operations of some predacious insects, as well as parasites, upon the San José scale, and when inspecting in Adams County, probably a year ago, it was a very difficult matter to find any live San José scale, although there was evidence of many trees that had never been sprayed having been badly infested. Two or three years previous to this I had reported the operations of parasites on the scale in my own county of Chester, and noticed the gradual disappearance of the scale. Not only in Adams and Chester Counties, but in Bucks and Berks Counties, I found the same conditions.

MR. D. G. TOWER: About a year ago while collecting parasites of the native scales at Amherst, this parasite was found in abundance. Dr. L. O. Howard kindly determined it as a new species and accordingly a description was published. Since then notes on its life history have also been published. Dr. Fernald announced that no hyperparasites had been found at Amherst and stated that parasites would be sent to those desiring them. I am inclined to think that hyperparasitism, if such is the case, will not greatly hinder the work of this parasite. Professor Parrott has shown that this parasite is the dominant one in New York. While I do not expect to see the scale cleaned up in a single case by this parasite, still in unsprayed or in orchards impracticable to spray, on ornamental shrubs and in forests, I think the work of this parasite will be of considerable value.

SECRETARY A. F. BURGESS: I would like to say a word in connection with the acceptance, without a great deal of consideration, of statements made by the average fruit-grower or person who is not a specialist in parasitic work on the results of introducing parasites. We have had considerable experience along this line on the gipsy and brown-tail moth work in New England, and we find that a great many people who know these pests thoroughly do not understand about the parasitic species introduced or the results that may be expected. They anticipate quick and immediate results whenever parasites are liberated, and if there is a decrease in numbers of the pests concerned, they immediately attribute this to colonization of parasites.

I am not speaking in regard to the parasites of the San José scale because we have had no experience with these but we are satisfied that the average farmer and fruit-grower, or other man, who has infested trees, is very apt to lay too much stress on the colonization of a parasite in his orchard or woodland if there is any decrease in the severity of the infestation.

MR. W. E. BRITTON: Perhaps Mr. Tower or someone else can give us an idea of the natural distribution of the parasites under consideration.

MR. D. G. TOWER: I have found the parasite in numerous places in Massachusetts and on the Capitol grounds at Washington, D. C. Specimens have been sent to me from Connecticut by Dr. Britton and from New York by Dr. Felt and Professor Parrott. Professor Surface has found it in many places in Pennsylvania. Specimens have been sent to Dr. Forbes in Illinois to start a colony there and I have attempted to start one at Lafayette, Indiana. Whether this last has been successful or not cannot be stated at this time. It is my opinion that in order to secure accurate data on the amount of parasitism, the scales should be examined for eggs, larvæ and pupæ of the parasite as well as a count of the exit holes made. The percentage of parasitism of the scales examined at Amherst would average, I think, from 75 to 85 per cent and it was evident that the parasite was doing good work. As regards the life-cycle of the parasite, it apparently coincides with that of the scale, in the majority of cases emerging from mature second stage female scales, The reason for some emerging from immature third stage female scales I have endeavored to explain in my recent paper.

PRESIDENT H. T. FERNALD: The next paper will be read by Mr. C. L. Metcalf.

A MECHANICAL MEASURE FOR CONTROLLING THE FLEA-BEETLE (EPITRIX FUSCULA) ON POTATO.[1]

By C. L. Metcalf, *Ohio State University, Columbus, Ohio*

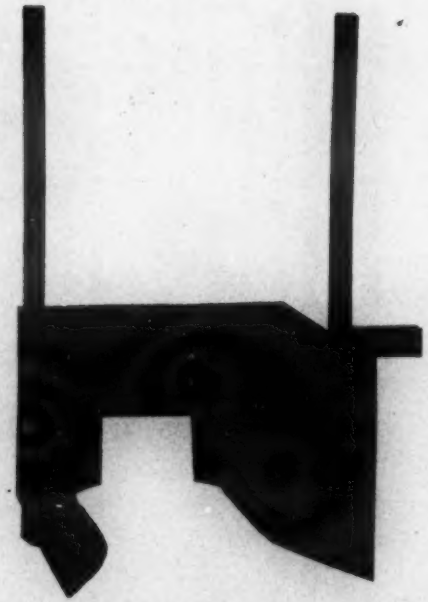
The difficulty of controlling flea-beetles with the known insecticides is generally appreciated. In North Carolina we tried a variety of materials without finding any really satisfactory insecticide. This fact and the well-known habit of these insects of jumping vigorously at the slightest disturbance, suggested to the writer that their economic control might be achieved by some method of trapping.

In 1913 a crude trap (Pl. 10, fig. 1) was improvised from a store box by cutting out one end, a part of the bottom and of the other end. The inside was covered with a thin coat of tree tanglefoot; and the box carried along the rows by the upright handles, so that the vines passed through the box from one end to the other. After covering one-fortieth of an acre of potatoes, moderately infested, a count showed 370 flea-beetles entangled in the trap. After covering one-fifth of an acre in the same way, 2,335 flea-beetles were counted in the tanglefoot. This was disposing of flea-beetles at the rate of 10,000 to 15,000 per acre, as rapidly as two men could walk along the rows.

A modification of the handle of the box so that one man could manipulate it was the most needed improvement. It was noticed at once that most of the beetles were caught on the lower part of the box, especially on the pieces (Pl. 10 fig. 2, A, A). It is, therefore, desirable to have these pieces extend inward as far as possible. It was also considered of some advantage to have a box wider in front than behind so that it might surround the vines before the insects became much disturbed. The opening at the rear (Pl. 10, fig. 2 B,) should be small to thoroughly disturb the vines as they pass. Two and a half to three feet seemed to be the best length for the box, while it should be just high enough and wide enough to cover the plants.

The leaves from the plants accumulated on the sides and back of the box; so a system of wires was devised running from the front to the opening at the rear. (See Plate 10, fig. 2). This effectually prevented the leaves from touching the sticky surface without affecting the efficiency of the trap. In order to facilitate the renewal of the tanglefoot surface, the wires were fastened in front to three wooden strips (Pl. 10, fig. 2, C, C, C) which in turn were attached to the box with thumb screws and so could easily be removed. It is believed to be essential for the highest efficiency that the trap precede the operator so that there is no disturbance of the vines until they are covered by the box.

[1] This work was carried on under the direction of Mr. Franklin Sherman, Jr., State Entomologist, Raleigh, N. C., to whom I am indebted for permission to publish it.



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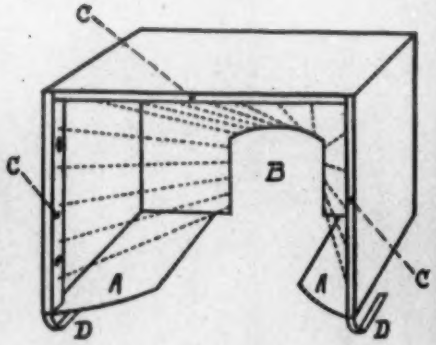

Fig. 2.

Flea Beetle Collector

With these points in mind a trap was devised in 1914 to run on light wheels (Pl. 10, fig. 3) in order to reduce the labor to a minimum. A pair of light springs should be fastened to the front of the box (Pl. 10, fig. 2, D, D) to prevent it from dipping into the soil, since otherwise a portion of the tanglefoot soon becomes covered with dust. This arrangement works nicely on even ground; but carrying the trap will probably be found to be more efficient. A count of the number of beetles caught by this trap showed 1,357 as a result of covering one-twentieth acre, which is at the rate of over 25,000 per acre.[1]

The expense involved in the use of such a trap should be moderate. A simple trap can be made by anyone in a few minutes. It is largely a matter of adapting the box to the size of the plants to be treated. When the sticky surface becomes matted over it may be renewed a time or two by scratching it with a wire comb or brush. Warming the tanglefoot made it easier to apply a thin even coat.

The ordinary routine spraying of potatoes will control the flea-beetles to some extent. However, from these preliminary experiments the apparatus described is believed to have a place in cases of severe infestation; and in caring for small areas of various garden crops which are attacked by one or another species of flea-beetle.

MR. T. J. HEADLEE: I would like to know whether these experiments have been tried on a large scale throughout the season for the purpose of determining whether potatoes can be protected in this way?

MR. C. L. METCALF: We had in mind to do this but the infestation of flea-beetles in North Carolina was 250 miles from our headquarters, and we found it absolutely impossible to use this trap at frequent intervals throughout the season. I am therefore unable to say but I see no reason why it might not.

VICE-PRESIDENT GLENN W. HERRICK: How often did the trap have to be coated inside?

MR. C. L. METCALF: That would vary greatly with conditions. We could cover as much as half an acre or an acre and then by scratching the surface slightly go on for a quarter of an acre farther perhaps. It would need to be removed altogether from five to perhaps ten or a dozen times in the course of a day.

PRESIDENT H. T. FERNALD: If there is no further discussion, we will now adjourn.

Session adjourned at 5.30 p. m.

[1]Incidentally a species of leaf-hopper (*Empoasca mali*) was taken at the rate of about 40,000 per acre.

Morning Session, Thursday, December 31, 1914, 9.00 a. m.

PRESIDENT H. T. FERNALD: The first paper on the program will be by Mr. J. M. Aldrich.

THE ECONOMIC RELATIONS OF THE SARCOPHAGIDÆ

By J. M. ALDRICH, *Assistant in Cereal and Forage Insect Investigations, Bureau of Entomology*

The classification of this family has been until within a few years in a very unsatisfactory condition throughout the world. However, the study of the male genitalia has recently solved the problem in Europe, and in that region the species of Sarcophaga are perhaps more satisfactorily distinguished now than those of any other large Muscoid group, although there is still much uncertainty as to where the limits of the group lie. Mr. Parker's work on the American species, beginning about two years ago, and my own beginning last winter, have shown conclusively that the North American species yield to the same treatment; while as yet we have no specific names for many of the forms, it will be only a matter of a year or so until this will be remedied. Meanwhile I wish to call attention to the larval habits of a considerable number of bred species which have passed through my hands for identification.

The notion that Sarcophagidæ are "flesh-flies" is derived from Linnæus and his predecessors, and is no doubt true as to the typical species *carnaria* in Europe; but it is very misleading in our fauna. Herms bred *S. assidua* and *sarraceniæ* from dead fish on the beach of Lake Erie, and I have collected adults of the latter on dead fish on the beach of Lake Michigan; Parker's new *cooleyi* feeds on dead fish in Montana; I have also noted adults of another species on dead snails along the banks of the lower Wabash River in Indiana. There is also the classical case of the larvæ of *S. sarraceniæ*, bred by Riley from the contents of the cups of *Sarracenia variolaris*. Several records of feeding in decomposing flesh of the warm-blooded animals, not yet published were communicated to me very recently, but the principal ones are from the far south (Texas).

The excrement of mammals furnishes a breeding-place for a considerable series of species: *S. assidua, cooleyi, hæmorrhoidalis, trivialis, incerta* and *lambens*, and *Ravinia communis, latisetosa, peniculata, quadrisetosa* and *trivialis* seem to be rather closely restricted to this breeding habit; *S. sarraceniæ* and *helicis*, which have also been reported, have other more common habits.

Parasitism on other Arthropods includes by far the largest part of

the records accumulated up to the present, and many of them are of considerable interest. Schiner in his Fauna Austriaca expressed a doubt whether the few recorded cases of his day might not be explained as carrion-feeding, the insects having died before the eggs of the fly were laid; and his doubt has curiously persisted and found frequent expression almost to the present time. But the large number and variety of the cases now known, many of them closely studied, permit no further doubt that Sarcophagas are generally parasitic in their habits. At least this is true with many of the species.

There are two records of rearing from scorpions, one from Sumatra of an undetermined species, the other *S. sternodontis* from one in Jamaica.

Egg-sacs of spiders furnish a nidus for *davidsonii*, reported only from California.

The adult of *Corydalis cornuta* has been attacked by *Sarcophaga helicis*, a series of bred flies with data being in the National Museum collection, dating from Riley's time.

Grasshoppers have furnished a large amount of bred material in several species: *S. helicis*, *hunteri*, *sarraceniæ*, *kellyi*, and the species heretofore erroneously known as *cimbicis*, are the ones most frequently bred in the West; of these *kellyi* is undoubtedly the commonest one. Mr. E. O. G. Kelly, in the *Journal of Agricultural Research* for September 21, 1914, has described its egg-laying habit. The female darts at the flying grasshopper and strikes it with enough force so that it instantly drops to the ground, when the larva of the fly can be found attached by a gluey secretion to the thorax or base of the wing. The fly also deposits larvæ on the quiescent, newly-moulted adult hopper while it is hardening, this involving an instinct-stimulus quite different from the other case.

A western species closely allied with *erythrura* of Europe has been found abundantly about grasshoppers in Colorado; the female fly has a fairly well-developed larvipositor, and presumably inserts its young under the body wall of the hopper, though this has not been observed. There is every reason to believe that in the arid west grasshoppers are normally kept within moderate numbers principally through the agency of the Sarcophagid parasites. In the east these are not so frequently reared; *sinuata*, *sarraceniæ* and *helicis* have been reported.

A specimen of *Cicada tibicen* was sent in to the Bureau of Entomology in August, 1894, from Waterfield, Va.; it was dead when received, and a number of dipterous larvæ had emerged, from which subsequently developed the ubiquitous *S. helicis*.

The question whether Sarcophagids are anything more than scaven-

gers in relation to lepidopterous larvæ and pupæ is discussed by Howard and Fiske, Bull. 91, Bur. Ent., 1911, p. 250, where it is stated that in imported gypsy moth material there have often been more Sarcophagid than tachinid puparia; notwithstanding this fact, absolute proof that the Sarcophagid larvæ invade living caterpillars is said to be lacking. The same conclusion was reached by Patterson (in Bull. 19. Tech. ser., Bur. Ent., part 3, 1911) as far as the Gipsy Moth is concerned; but he did not distinguish species at all in his experiments, hence may have been using the common excrement-feeding *Ravinia communis* when he attempted without success to induce the flies to larviposit on living caterpillars. I can supply the missing proof in one instance:—living larvæ of the Army Worm moth were brought into the Bureau insectary at Lafayette last summer by Mr. J. J. Davis and assistants, confined in breeding cages, and yielded 30 or more adults of *Sarcophaga helicis*—more of these than of any Tachinid parasites. Since the Sarcophagids have been seen to larviposit on living grasshoppers, and as I shall show farther on, also upon living beetles, it becomes easier to admit that they parasitize caterpillars. The records include undetermined Sarcophagas attacking *Alabama argillacea*, *Acronycta ovata*, and *Phakellura hyalinitalis*; *S. helicis* on *Loxostege sticticalis*, *Pieris* and the Army Worm; *hunteri* on Army worm, and even the Codling Moth; and *amblycoryphæ* on *Amblycorypha oblongifolia*.

The only record relating to Hymenoptera that I have found is that of *Sarcophaga* (*Bæticheria*) *cimbicis* Townsend, of which the types were bred from larvæ of *Cimbex americana*. Other published records for *cimbicis* are all due to misidentification, as I lately learned from an examination of the types; the species has been bred only once.

Sarcophagas have been bred several times from beetles, usually from the adults.

On May 13, 1893, 34 adults of *Lachnosterna arcuata* were collected in Washington and placed in a breeding cage. From these there emerged several specimens of *S. helicis*, which matured in July.

On March 4, there were received in the Bureau living larvæ of the beetle, *Dinapate wrightii*, in a piece of palm trunk from Southern California, sent in by H. G. Hubbard. Two adult beetles emerged in July and August, and on September 2 there came out of one of these adults several dipterous larvæ, which gave *S. helicis* on September 11.

On September 13, 1894, two specimens of the same fly issued in a jar which had contained larvæ of *Calosoma* sp.

In the summer of 1914, Mr. D. E. Flnk, of the Bureau of Entomology, bred *S. sarraceniæ*, *helicis*, and a new species, from *Allorhina*

nitida—the first from a pupa, the last two from adults. This was at Norfolk, Va.

On August 16, 1914, Mr. W. R. Walton, of the Bureau of Entomology, near Cimarron, N. M., captured a female Sarcophaga in the act of larvipositing on the body of an adult living specimen of *Eleodes hispilabris*. In September of the same season, at Koehler, N. M., Professor H. F. Wickham reared several specimens of the same fly from adults of *Eleodes tricostata* and *obsoleta*. In reply to an inquiry as to the possibility of the fly larvipositing only on dead beetles, Professor Wickham wrote: "There is no doubt that all of the Eleodes of mine from which Sarcophaga larvæ were secured had already been infested before being placed in the cages in which the food experiments were carried on. These cages were all closed with wire screen over the tops, the cages themselves being of the battery jar type. In most of them the top had been made of wood with a central circular opening which was covered with the wire mesh. . . . My practise was to take an Eleodes out of the cage as soon as it was noticed to be dead and place it in a vial covered with fine cheesecloth. Sometimes the larva left the beetle within an hour or less, at other times it remained for several weeks. In no case has a beetle been left where it could have been 'blown' by a free fly."

How the larva of Sarcophaga manages to penetrate the armor of an adult Eleodes has not been ascertained.

In November, 1914, at the University of Kansas, Mr. H. B. Hungerford showed me specimens of an undescribed species of Sarcophaga, which he had bred from adults of the longicorn Cottonwood Borer, *Plectrodera scalator*, at Kinsley, Edwards Co., Kansas; the flies were numerous, affecting 90 per cent of the beetles.

A few scattering records may be added.

Human beings are occasionally affected, but in various ways: one instance of intestinal myiasis, one of nasal, one larva in the ear, and one in a tumor on the back, are on record in this country. None of the species have been identified except the one in the intestine, which was *Ravinia trivialis*, normally an excrement-feeding form.

Sarcophaga helicis, as the name implies, was originally bred from a snail.

Undetermined species have several times been bred from tumors on the neck of tortoises.

Cole bred two undetermined species from rotting kelp on the seashore at Laguna, Cal. (Pom. Coll. Jour. Ent., iv, 840).

Only a few of the species so far have shown a wide range of adaptability in larval habit; but this may very likely be a conclusion from too few cases. *Helicis* has been bred from a snail, Corydalis, Cicada,

several Lepidopterous larvæ, several adult beetles, several grass hoppers and a Mantis, and according to one record from cow manure, though I am skeptical about this. *Sarraceniæ* without doubt breeds at times in dead fish and is at other times a parasite of insects; it has even been recorded from human excrement, but this might have been a misidentification.

We seem to be dealing with a group in which the parasitic habit is just being formed, and is still much more plastic than is the case with Tachinidæ, connecting the latter with the true Muscids—just where, by good luck, we happen to have placed them in our lists.

MR. R. R. PARKER: I would like to add a few words to what Dr. Aldrich has said, and shall deal mainly with their excreta-frequenting habits. My data are based principally on personal observations made during the past summer while carrying on investigations for the Montana State Board of Entomology, undertaken in part to determine what Montana flies may be considered of actual or potential importance as disease agents or as carriers of disease.

In one experiment in which a trap was attached to the back of a privy with a sunken vault so as to catch the flies which had visited the excreta, 43 Sarcophagids were captured in one month, about 0.5 per cent of the total catch, and these were principally *Sarcophaga cooleyi* R. Pkr., a species not known to breed in excreta.

Of flies captured with excreta as bait, Sarcophagids constituted 8.75 per cent of the catch in seven experiments. Of these, *Ravinia communis* R. Pkr. was the most numerous and specimens of *R. peniculata* R. Pkr., *Sarcophaga hæmorrhoidalis* Meig. and *S. cooleyi* R. Pkr. were also taken. All were females except a few specimens of *S. hæmorrhoidalis*. It is interesting to note that the great majority of oviparous species were also females.

Of flies noted in houses no proportionate record was kept, but specimens of *Ravinia communis* R. Pkr., *R. peniculata* R. Pkr., *Sarcophaga hæmorrhoidalis* Meig. and *S. cooleyi* R. Pkr. were either captured or observed, though only occasionally. Under certain conditions, such as those prevailing in construction camps, it is probable that a larger proportion of these flies would be found frequenting food, than under town or city conditions.

The most interesting results were obtained from breeding experiments. From material taken from privies with sunken vaults no Sarcophagids were reared, but only oviparous species, mainly *Ophyra leucostoma* Weid., and species of *Fannia*, *Limosina* and *Scatopse*. On the other hand, when dealing with material exposed in the open,

Sarcophagids were reared almost to the exclusion of oviparous forms, the latter consisting principally of *Muscina stabulans* (Fall). While the number of experiments was too limited to permit of definite conclusions, they did indicate that where surface excreta and that from surface privies was concerned, the Sarcophagids apparently prevented the oviparous species from breeding in any great numbers. This may be due to the Sarcophagid larvæ preying upon the others, or they may be more successful in the struggle for food; at least they have the advantage of being deposited as larvæ. I would not care to suggest that this relationship would hold farther south where there are more oviparous forms which breed in excreta. As Sarcophagids are less numerous and less commonly found in houses than oviparous species that frequent excreta, they may perhaps be considered beneficial in so far as the relationship suggested above holds good. In one experiment, 970 Sarcophagids were reared from a single stool which was found in a back alley and had been exposed one day; 944 of these were *Ravinia peniculata* R. Pkr. *Sarcophaga tuberosa sarraceniæ* (Riley) was bred from fish, but was not found in excreta though supposed to frequent it abundantly. *S. cooleyi* R. Pkr. was bred in large numbers from fish, and also from the carcass of a kitten.

The species of *Ravinia* are probably primarily breeders in excrementous substances, and when excreta is deposited in the open are commonly the first flies to be found on it. *Ravinia communis* R. Pkr. was bred from human excrement, cow dung, horse manure, hen manure and pig manure; *R. peniculata* R. Pkr. from human excrement and cow and pig manure; several other species, some undescribed, are also known to breed in manures of various kinds. There are very few records of these species under other conditions. I also have records of excreta-frequenting habits for several undescribed species of *Sarcophaga*. These flies also frequent garbage to some extent as it is found exposed in the vicinity of stores and residences.

PRESIDENT H. T. FERNALD: I suppose all economic entomologists fully appreciate the necessary foundation of systematic work upon which their studies must rest. It has been of interest to me in examining collections throughout the country, as I have had the opportunity, to note the number of Sarcophagidæ labeled "Sarcophaga sp."

I think we are to be congratulated on the fact that since Mr. Aldrich, Mr. Parker and others have been doing so much work along this line, this unsatisfactory condition promises shortly to be removed and that economic studies of the Sarcophagidæ may apply to the particular species concerned in each case.

PRESIDENT H. T. FERNALD: The next paper on the program will be by Mr. J. W. McColloch.

FURTHER DATA ON THE LIFE ECONOMY OF THE CHINCH BUG EGG PARASITE

By J. W. McColloch, *Assistant Entomologist*, and H. Yuasa, *Assistant in Life History Studies, Kansas Agricultural Experiment Station*

At the annual meeting of this association last year the writers presented a paper on "A New Parasite of the Chinch Bug Egg, *Eumicrosoma benefica* Gahan." This paper was a preliminary report based on the first year's study and consequently the results were subject to some modification as the work progressed.

As the habits of the insect under consideration became better understood and the technique of rearing and handling developed, more accurate results were obtained. Owing to many unforeseen circumstances which arose during the first year's work, the study of the life history suffered several reversals and a complete life history was not worked out. During the past summer these circumstances were anticipated and a continuous life history study was made. By the development of certain methods of technique it was also possible to observe the growth of the various stages within the host egg and to dissect out the different stages for a more detailed study.

During the past summer about 4,500 parasites were reared and a large amount of data was collected. While most of the results coördinate those obtained in 1913, some of them show considerable variation. As the work of this year was carried on under more improved methods, which conform more nearly with the natural habits of this insect, it would seem that the results are more typical of the life of this parasite under natural conditions.

History and Distribution

The history of *Eumicrosoma benefica* began in May, 1913, when it was found parasitizing chinch bug eggs in the vicinity of Manhattan, Kansas. During the summer of that year it was taken in sixteen counties in Kansas comprising most of the area of chinch bug infestation. Five counties have been added to this list during the past summer, namely, Finney, Sedgwick, Butler, Elk, and Miami.

Mr. W. B. Flint, assistant state entomologist of Illinois, reports finding parasites in limited numbers in a few localities in that state. It is probable that the parasite is also present in Oklahoma and Missouri, as it has been taken many times in Kansas within a few miles of the borders of these states.

Importance

From the data thus far accumulated the egg parasite is an important factor in the control of the chinch bug. In the spring of 1913 the emergence of chinch bugs from winter quarters was one of the largest ever witnessed in Kansas and the indications were for serious injury during the ensuing summer. Within two weeks after this emergence the wheat fields were beginning to show considerable damage and a few fields were entirely destroyed. Hundreds of eggs were deposited around nearly every wheat plant and it was thought that the wheat and corn fields in many localities would be practically a total loss. In two or three weeks it was evident that a large percentage of the eggs were not hatching as the number of young bugs was far below the expectation. At harvest when the bugs migrated to the corn fields there was very little complaint of injury and throughout August the number of bugs in the corn was exceptionally low. In the fall of 1913 the counts of the number of bugs in winter quarters showed only one bug where there were from twenty-five to one hundred in the fall of 1912.

The climatic conditions during 1913 were favorable for the development of the chinch bug. The drought during the summer prevented the development of the chinch bug fungus and there was no known factor except the parasite which could have caused this great reduction. In Illinois, where practically the same conditions existed as in Kansas, with the exception that there were few parasites present, the chinch bugs did a vast amount of damage in 1913 and were equally bad in 1914.

In 1913 the average parasitism at Manhattan during the summer was 32 per cent and during the spring when chinch bugs were most numerous it ranged from 20 to 40 per cent. In the experimental work it was shown that the period of oviposition of the chinch bug covered about two months, while the life cycle of the parasite extended over a period of only two or three weeks. Thus the eggs of a single female chinch bug were exposed to about three broods of parasites while the eggs of one brood of chinch bugs were exposed to four or five broods of parasites. From this data it is conservative to estimate the parasitism in the field during 1913 to have been at least 50 per cent.

The number of chinch bugs in the fields about Manhattan in 1914 was exceptionally small and there was a marked reduction in the number of parasites. The parasitism in the early spring was considerably below one per cent, but as the summer progressed it gradually increased until in September it reached 25 per cent. Table I gives the percentage of parasitism by months at Manhattan.

TABLE 1. SHOWING THE AVERAGE PERCENTAGE OF PARASITISM AT MANHATTAN, KANSAS, IN 1914

Month	*No. of Eggs*	*Per Cent of Parasitism*
May	3,002	0.16
June	1,204	5.2
July	4,989	6.3
August	1,777	9.0
September	28	25.0

Collections of eggs were made in sixteen localities in the state during July and August and the average parasitism for the state exclusive of Manhattan was 14.5 per cent.

THE EGG

DESCRIPTION.—Fully developed eggs were readily dissected from the abdomen of the adult female and in a number of instances eggs were dissected from the host egg soon after oviposition. The egg (Fig. 11, A) is ovate in shape and tapers into a long stalk at one end. The opposite end tapers gradually and ends in a blunt point. The stalk is about two-fifths of the entire length of the egg and the micropyle is located at its tip. The comparatively large nucleus is located near the blunt end. The egg is 0.23 mm. in length and 0.07 mm. in width.

DEVELOPMENT.—Shortly after deposition the egg begins to swell due to embryonic development. In one instance an egg was removed four hours after deposition. It had increased in volume, had become spherical in shape and the protoplasmic content had begun to appear differentiated but had not developed sufficiently to show any definite form.

LENGTH OF EGG STAGE.—The length of the egg stage was determined in a number of cases and was found to vary from a few hours to about one day. During midsummer eggs deposited about 6.00 p.m. hatched before 7.00 the following morning.

THE LARVA

DESCRIPTION.—In the life history two distinct larval stages were found. The first stage (Fig. 11, B) resembles closely the first larval stage of Teleas as described by Ganin.[1] The larva when first hatched is about one-fifth the size of the host egg. It is supplied with a large pair of mandibles which are strongly chitinized and each bears a sharp claw at the outer extremity. The caudal extremity ends in a long tail-like process which is about one-half of the length of the body. No segmentation was distinguished but there is a marked constriction between the head and the body region.

[1] Ganin, M., 1869. Beiträge zur Erkenntniss der Entwickelungsgeschichte bei den Insekten. Zeits. wiss. Zool., bd. 19, pp. 381–451, 4 taf.

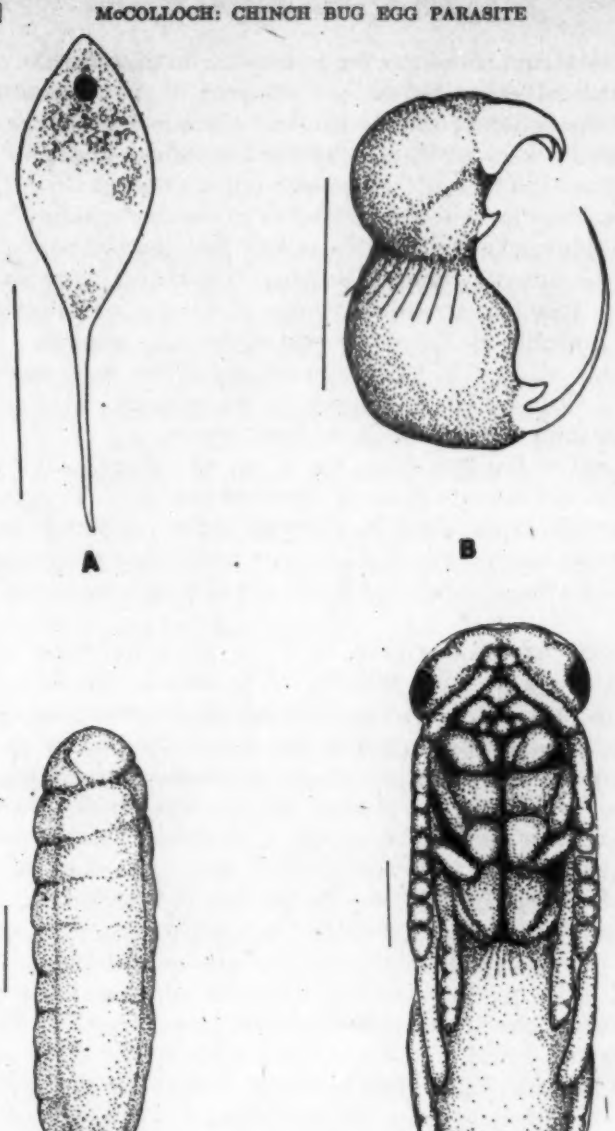

Fig. 11 — Different stages of *Eumicrosoma benefica* Gahan. (*A*) Egg. (*B*) First stage larva. (*C*) Second stage larva. (*D*) Pupa. All greatly enlarged, the hairline being $^1/_{10}$ mm. magnified to the same scale as the object. (Original.)

The larva is capable of moving from place to place within the host egg, locomotion being effected by the lashing of the tail and to some extent by the action of the mandibles. During the early part of its life the larva is very active and by the continual working of the tail and mandibles the contents of the host egg are disorganized.

The first stage larva feeds by a series of sucking motions by which the food is drawn in through the mouth into the pharynx and from here into the stomach, which is nothing more than a blind sac. Here the food is rolled backward and forward by the movements of the larva and probably by the contraction of the body muscles.

The length of the first larval stage is about two or three days and during this time the larva increases to about twice the original size, most of the growth occurring in the body region.

At the end of the first stage, the larva, which has lost its external constriction and is ovate in shape, becomes inactive. Transformation takes place within the old skin, the body shrinking back from the old cuticula which has become thin and soon bursts near the cephalic end. The larva gradually moves out of the old skin and the moult is complete.

The second larval stage (Fig. 11, C) is ovate in shape and occupies about two-fifths of the host egg. The tail-like process of the preceding stage has disappeared and the mandibles have become greatly reduced in size. Segmentation of the body shows faintly and ten or eleven segments can be distinguished. Tracheation becomes apparent in this stage and four or five pairs of well developed spiracles are noticeable. This stage feeds in much the same manner as the first larval stage. The food is apparently sucked into the pharynx, passing through the oesophagus to the stomach where digestion occurs. The stomach is a blind sac and until just before pupation no excrement is voided. Digestion is facilitated by the constant churning of the food back and forth by the contractions of the muscles of the stomach. These contractions are somewhat regular in occurrence. They may start from either end of the body and move to the other end, they may start simultaneously from each end of the body and move to the center, or they may start at the center and run to each end. About three contractions start from the anterior end to one from the posterior and there are about two contractions per minute.

In about three days the larva has reached its full development and is ready to pupate. At this time all the contents of the chinch bug egg have been destroyed and the larva nearly fills the shell.

Length of Larval Stage.—It was possible to carry a number of larvæ through to pupation and thus the length of this period was determined. During August several larvæ were kept under constant obser-

vation. The first larval stage was completed in two or three days while the second larval stage required from three to four days. Another day or two was required for molting and for the excretion of waste. The total length of the larval stage varied from six to eight days.

The Pupa

Formation.—Just before pupation begins the larva ceases to feed and the waste matter which has accumulated within the body of the larva during its growth is deposited at the posterior end of the host egg. In a short time the body begins to constrict between the thorax and the abdomen. Subsequently the eye spots begin to appear. In a day or two the appendages begin to appear and pigmentation becomes apparent in the head, thorax, and body (Fig. 11, D). The transformation is completed in about eleven days and the adult emerges shortly after.

Length of Stage.—The pupal stage covers about three-fourths of the length of the life cycle: During August and early September a number of pupæ under constant observation required from eleven to thirteen days to complete this stage.

The Adult

Description.—The adult form (Figure 12) was described last year by Mr. A. B. Gahan,[1] entomological assistant of the United States Bureau of Entomology and his description was given in the previous paper.

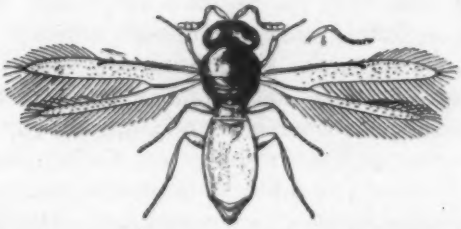

Fig. 12—*Eumicrosoma benefica;* adult. Greatly enlarged (After Gahan).

During the past summer a melanic form was reared in the fourth generation which differed from the form described by Mr. Gahan in that the entire body was black. By crossing with the normal form it was possible to carry this form through the remaining generations. During this time eighty-six black females and sixty black males were reared. On August 19 a black male was reared from a chinch bug egg collected in the field.

[1] Gahan, A. B., 1914. New Hymenoptera from North America. Proc. U. S. Nat. Mus., Vol. 46, pp. 442–43.

TIME OF EMERGENCE.—Considerable data was collected on the time of emergence of the adult parasite. During the life history study all material was examined at 8.00 a. m. and 5.00 p. m. each day for the emergence of parasites. In this way it was found that the optimum time for emergence was between 5.00 p. m. and 8.00 a. m. Of the 4,474 parasites bred during the season, 4,136 parasites, or 92 per cent, emerged during the night, while 342, or 8 per cent, emerged during the day. In order to determine the exact time of emergence 309 parasitized eggs were kept under hourly observation from July 31 to August 12. Two hundred and seventy-six, or 88 per cent of these parasites, emerged between the hours of 6.00 a. m. and 9.00 a. m., the maximum emergence occurring between 6.00 and 7.00.

PERIOD OF EMERGENCE.—The emergence from parasite eggs laid on the same day may extend over a period of from three to fifteen days. During the summer months this period varied from three to six days, the maximum emergence occurring the second or third day. In the fall this period was prolonged to from eleven to fifteen days.

RELATION AND ECONOMY OF SEXES.—In a number of experiments conducted to determine the relation and economy of sexes, it was found that one male could fertilize as many as ten females and that one female could mate with as many as six males. It was also found that when oviposition occurred without mating all of the offspring were males. When mating occurred about 70 per cent of the offspring were females. The factor that influenced the number of eggs parasitized per female was the number of eggs supplied. This factor also influenced the mortality of the parasites in the host egg. When few eggs were supplied double parasitism often resulted.

METHOD OF OVIPOSITION.—Oviposition was observed many times under laboratory conditions and in practically every case the process was the same. The female parasite, on finding an egg, hurriedly makes a preliminary survey of it by crawling over the egg and feeling it with her antennæ. Generally, the female in making this examination goes over the entire egg, the progress being along the long axis. If the egg does not suit she may discard it after this examination. If the preliminary survey proves satisfactory, a more careful survey is made in which the female goes over the egg slowly and examines every part of it carefully by tapping with the antennæ. If this examination proves all right the female crawls off the egg and with her back to it endeavors to find a suitable place for the insertion of the ovipositor. The latter is protruded until it touches the egg and then the female begins a survey by sounding various parts of the egg with the tip of the ovipositor. Often it is necessary for her to change position once or twice before a suitable place for its insertion is found. When a

place is found the actual insertion takes place. The parasite assumes a rigid position, the tip of the ovipositor touching the surface of the egg. The two pieces composing the sheath of the ovipositor are then pushed and withdrawn alternately for some time until a hole is made in the shell. The inner valve of the ovipositor, which is chitinized and sharp, is then suddenly thrust into the egg. Oviposition immediately follows this procedure and is distinguishable by a slight swelling which starts at the base of the ovipositor and passes in a wave-like motion to its tip. Immediately following oviposition the inner valve of the ovipositor is withdrawn and at the same time the caudal segments of the abdomen are extended to the surface of the chinch bug egg and the ovipositor is then withdrawn.

The female may then walk away or she may endeavor to oviposit again in the same egg. The entire process of egg deposition may require from one to five minutes. The parasites do not seem able to distinguish parasitized eggs from normal ones. In the course of the season females were observed ovipositing in parasitized eggs, egg shells from which chinch bugs or parasites had emerged and eggs from which parasites were emerging. As many as three females were seen ovipoisting in the same egg at the same time. At no time was a female seen attempting to parasitize eggs other than those of the chinch bug.

Oviposition may occur at any time of the day or night. In the laboratory parasites were supplied with eggs at all hours and egg laying occurred soon after. Parasites confined in darkness were fully as prolific as those kept under normal conditions.

The period of oviposition may extend from two to eleven days, the maximum deposition usually occurring the first or second day.

Number of Eggs.—The number of eggs that a female could deposit was determined for about 300 individuals and was found to vary to a great degree. This variation was due to a number of factors, such as the number of chinch bug eggs supplied, the age of the eggs, food, fertilization, and age of the female.

Two hundred and twenty-six females parasitized an average of 16 chinch bug eggs or 53.5 per cent of the eggs supplied. The largest number of eggs deposited by a single female was 54 and this was by an unmated female. Seven females deposited over 40 eggs each and twenty-one females deposited over 30 eggs each.

Sixty females that had not been allowed to oviposit were dissected and the number of eggs in the ovaries counted. The largest number of eggs found was 36 and the lowest 5, while the average was 22.

Thirty-nine females that had been supplied regularly with chinch bug eggs were dissected after death and the average number of eggs remaining in the ovaries was 11.4 with extremes of 0 and 28.

DOUBLE PARASITISM.—The female parasite does not seem to be able to distinguish between parasitized and unparasitized eggs and double parasitism often resulted. If double parasitism occurs at about the same time it results in the death of both larvæ, while they are in the first larval stage. If the second parasitism occurs when the first parasite is in the pupal stage, the second parasite makes no development and the first parasite emerges.

In the case of simultaneous double parasitism the eggs hatch in about the normal length of time but the resulting larvæ develop slowly and never reach the second larval stage. These larvæ may live from nine to twelve days, usually one of them dying two or three days before the other.

PARTHENOGENESIS.—*Eumicrosoma benefica* can reproduce parthenogenetically but the percentage of eggs parasitized and the number of eggs parasitized per female is usually low. Twenty-three unfertilized females were supplied with eggs in the life history work. Of the 620 eggs supplied 239, or 38.5 per cent, were parasitized, an average of ten eggs per female. Two hundred and seven parasites were reared and 206 were males.

PROPORTION OF SEXES.—In the study this year the number of females greatly exceeded the number of males. Of the 4,474 parasites reared during the past summer 3,176, or 71 per cent, were females, while 1,297, or 29 per cent, were males. Sexual reproduction, however, seems to be the rule, for of the 468 parasites bred from eggs collected in the field, 336 were females and 132 were males. In the laboratory studies unmated females always produced males.

EFFECT OF OVIPOSITION IN DIFFERENT STAGES OF THE HOST EGG.—The parasites show a decided preference for chinch bug eggs that are from one to three days old and the best results were obtained in laboratory studies when eggs of this age were used. A number of experiments were conducted in which parasites were supplied with eggs ranging in age from two to fourteen days. Parasitism occurred in all of these eggs but the percentage of parasitism decreased as the age increased.

HOST RELATIONS.—Numerous experiments were conducted again this year in an effort to rear *Eumicrosoma benefica* on some host other than chinch bug eggs but all proved negative. The parasites were supplied with eggs of *Nysius angustatus*, *Geocoris* sp., and of several species of Jassidæ. Large numbers of these eggs were also collected from grass containing parasitized chinch bug eggs and these were carefully examined for parasites but no evidence of parasitism by *Eumicrosoma benefica* was noted.

LENGTH OF LIFE.—The length of adult life was found to vary from a few hours to seventy-eight days. Temperature is probably the most

important factor which influences the length of life, and food is the next most important. During midsummer the average length of life was about four or five days, but with the advent of cool weather it increased to from 15 to 25 days. Seven parasites that emerged about the middle of September lived over 60 days and one lived 78 days. Parasites fed on sweetened water lived much longer than those that were not fed.

Length of Life Cycle

The length of the life cycle varies with the season of the year. During the early spring and late fall the life cycle averaged from 30 to 42 days, while during June, July, and most of August it averaged about 16 days, with a range of from 11 to 23 days. Between May 6 and October 21, 4346 parasites were reared and the average length of the life cycle was 18.3 days, with a range of from 11 to 42 days.

Table 2 gives the length of the life cycle based on the period between first oviposition and first emergence in the continuous life history study. Table 3 gives the average length of the life cycle for all parasites reared in each brood of the life history work.

Table 2. Showing Length of Life Cycle in Life History Study

Brood	*First Oviposition*	*First Emergence*	*Length of Life Cycle*
1	(3)		
2	May 6	May 27	22 days
3	May 28	June 11	15 days
4	June 12	June 28	16 days
5	June 29	July 15	16 days
6	July 16	July 31	15 days
7	July 31	Aug. 15	15 days
8	Aug. 15	Sept. 1	17 days
9	Sept. 1	Sept. 24	23 days

(3) The first brood of adults was present in the field prior to May 6.

Table 3. Showing the Average Length of Life Cycle of All Parasites Reared.

Brood	Source	Date	No. of Parasites	Av. Length of Life Cycle	Range	
					Max.	Min.
				Days	Days	Days
2	From field collection	5-6 to 9-7	463	10.7	31	2
3	From 2nd brood	5-28 to 7-31	799	16.0	21	12
4	From 3d brood	6-11 to 8-4	932	16.0	21	12
5	From 4th brood	6-29 to 8-8	279	16.4	20	13
6	From 5th brood	7-16 to 7-31	978	15.7	23	12
7	From 6th brood	7-31 to 8-10	567	16.0	22	11
8	From 7th brood	8-15 to 8-29	266	20.0	28	16
9	From 8th brood	9-1 to 9-10	62	28.0	42	23

Period of Activity

Since the first parasitized chinch bug eggs were found on May 6 it is evident that the parasites were active before this date. The first chinch bug eggs were found on May 5.

The last emergence of parasites in the life history study in the outdoor insectary under practically natural conditions occurred October 21 and the last parasite died November 30. The period from the first parasitism in the spring to the last emergence in the fall was 168 days and to the last death 209 days.

Number of Generations

The possible number of broods was determined in an outdoor insectary by collecting parasitized chinch bug eggs as soon as they appeared in the field in the spring and rearing adult parasites. The adults were allowed to oviposit in chinch bug eggs immediately and in this way the next generation was obtained. By supplying the first adults of each generation with fresh chinch bug eggs an unbroken life history record for the entire summer was obtained. The first brood of adults was present in the field prior to May 6 as parasitized eggs were found at this date. The second brood of adults was bred from eggs on May 27, the third brood was out June 11, the fourth brood June 28, the fifth brood July 15, the sixth brood July 31, the seventh brood August 15, the eighth brood September 1, and the ninth brood September 24. The first pair of adults of the ninth generation was supplied with 17 chinch bug eggs and oviposition occurred at once. The larvæ of this brood, however, died just before pupation. The accompanying chart gives the seasonal life history and brood study at Manhattan.

Physiological Relations

Effect of Temperature.—*Eumicrosoma benefica* responds readily to temperature influences. Low temperatures of from 40° to 50° prolong the life cycle from sixteen days to forty-two or more days and prolong the length of adult life from three to ten days to as high as seventy-eight days. On July 13 several parasitized eggs were placed in an ice box where the temperature ranged between 42° F. and 55° F. One egg was removed each week and the time of emergence was prolonged just the period that the eggs remained in cold storage. The parasite that was in cold storage seven days emerged seven days later than the check, and the parasite that was in twenty-nine days emerged twenty-nine days later than normal.

On August 8 eighty-four parasites were fed on sweetened water and placed in an ice box where the temperature ranged between 40° F. and

55° F. The average length of life of these parasites was nineteen days, with extremes of eleven and twenty-seven days. Seventy-eight parasites in the check lived an average of 3.5 days, with extremes of two and five days.

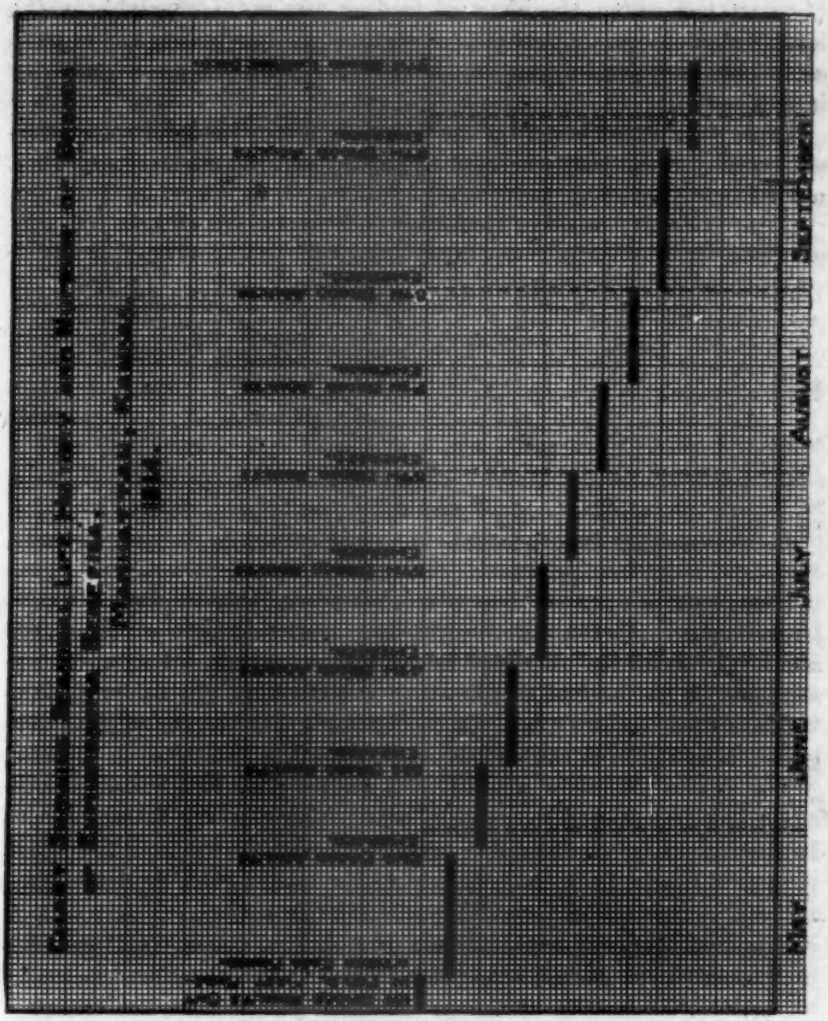

Fig. 13—Life History Chart.

Temperatures above 100° F. for three or four hours were fatal to the adult parasites when they were confined in small vials, and temperatures above 110° were fatal to the immature stages under the same conditions.

EFFECT OF FOOD.—During the summer the parasites were fed on numerous substances, such as sweetened water, plain water, dew on corn plants, sap from corn stalks and gummy secretions from sunflowers. In all cases the parasites fed readily, but, with the exception of sweetened water, the effect of feeding was not appreciable in the length of life or in oviposition. Sweetened water prolonged life from a few days to several weeks and the parasites showed a greater activity in oviposition.

Table 4 gives the effect on the length of life of the adults at different seasons of the year when fed sweetened and plain water, and when not fed.

TABLE 4. SHOWING EFFECT OF FOOD ON LENGTH OF LIFE

Date	Sweetened Water		Plain Water		No Food	
	No. Parasites	Length of Life	No. Parasites	Length of Life	No. Parasites	Length of Life
		Days		Days		Days
June	17	16.5			6	4.0
7-16 to 8-1	120	7.0	3	3.6	86	3.3
8-7 to 8-17	127	10.3	48	3.0	138	3.9
9-4 to 9-17	96	9.6	35	9.2	71	9.5
9-24 to 10-17	14	26.2	9	18.0	33	15.5

EFFECT OF LIGHT AND CONTACT.—The adult parasites show negative phototropism. In the vials they always crawled in between the cotton and the glass on the underside where it was darkest. If a paper label were placed in the vial the parasites would get on the under surface. When placed in a dark box which had a glass tube inserted for emergence to light the parasites seldom appeared in the tube.

The adults also show a positive thigmotropism and whenever possible they endeavored to crawl in between two closely fitting objects. In the vials they were found wedged in between the vial and the cotton plug and in the field they were often found between the leaf sheath and stalk of plants or in small cracks in the ground.

The two reactions are necessary in the life economy of the insect in its search for chinch bug eggs.

A MEMBER: I would like to ask as to whether this parasite has transferred its habitat to the chinch bug or whether it has been present all the time in small numbers?

MR. J. W. MCCOLLOCH: Indications are that it has been present for some time. The percentage of parasitism the first year we found

the parasite was about the same in all parts of Kansas under various atmospheric and soil conditions. About 16 per cent of the eggs collected in the field were parasitized. This year 14 per cent of the eggs collected in the field outside of Manhattan were parasitized.

PRESIDENT H. T. FERNALD: The next paper on the program will be read by Mr. W. R. McConnell.

A UNIQUE TYPE OF INSECT INJURY

By W. R. McCONNELL, *Bureau of Entomology.*

INTRODUCTION

The bean-leaf beetle, *Cerotoma trifurcata* Forst., is well-known in the south as an enemy of beans and cowpeas. It is known chiefly from the damage done by the adults to the foliage of these hosts, where its injury may consist merely of eating rounded holes in the leaves or may extend to the total destruction, particularly of young plants.

The first record of a food plant was made in 1877 by Professor E. A. Popenoe[1] who found the beetles damaging the leaves of garden beans in Kansas. In 1887, Professor F. M. Webster[2] recorded the total destruction of garden beans in Louisiana and Indiana. He also found cowpeas seriously damaged in Louisiana and predicted that "To the cowpea this may prove a formidable enemy, especially in the south." Popenoe later published a more complete account[3] and Dr. Chittenden[4,5] has published several important papers on this insect, giving notes upon several additional food plants, upon its life history, and recording injurious outbreaks as far north as New Jersey. A few other writers, particularly H. E. Weed,[6] have added important facts regarding this insect.

The larvæ have been described a number of times as feeding on the roots, channeling furrows in the bark of the subterranean portion of the stem, and even as burrowing up through the stem. While all these forms of injury may take place, it is evident that they are not sufficient to account for all the phenomena of the distribution and extent of damage in bean and pea fields.

In the fall of 1912, Mr. T. H. Parks, formerly of the Bureau of Entomology, and the writer, while working in the lower Mississippi Valley, discovered that the nodules on the roots of cowpeas had been damaged by larvæ resembling those of *Diabrotica*. Adults of the bean-leaf beetle were feeding upon the foliage and we suspected that the larvæ might belong to this species. The unique character of this injury led us to believe that a careful study of these larvæ in relation

to cowpeas should be made, and it was agreed that Mr. Parks should concentrate his attention upon this problem. He soon proved the identity of the larvæ and did the major portion of the work until his resignation in the following spring, when the writer took it up. The full possibilities of the damage began to be realized during the following summer when the larvæ were found to be the most destructive on the poor soils where soil enrichment through the growth of cowpeas was of the greatest consequence, and when soy beans were found to be seriously damaged in the same way. The present preliminary paper includes none of the results of the past season during which active work had been turned over to other hands, but the results obtained up to that time are deemed important enough for publication now.

Distribution

The bean-leaf beetle is found over the eastern portion of the country from New York to Minnesota and southward to Kansas and the Gulf of Mexico. It occurs in most destructive numbers in the south, especially in the Gulf Coast States.

Food-Plants

It feeds on a rather long list of plants, all of which are legumes. Recorded host plants include bush and pole beans, cowpeas, bush clover (*Lespedeza* spp.), hog peanuts (*Falcata comosa* L.), and tick trefoil or beggar weed (*Meibomia* spp.), including the cultivated beggar weed. Parks found adults on the leaves of English horse-beans (*Faba* sp.) at Biloxi, Mississippi, and pupæ near characteristically injured nodules of soy beans. The writer has found soy beans seriously damaged in Louisiana and has reared larvæ from this host. He has also found the larvæ damaging nodules on some recently introduced forage plants, such as the moth bean, Kulthi bean, and *Phaseolus* sp. In the delta region of Mississippi *Meibomia canescens* seems to be a native food plant and its nodules are damaged in the typical way. Garden peas and velvet beans seem to be exempt.

Life-History

The notes on life-history apply to the latitude of central Mississippi, most of this work being done at Greenwood. Here there are at least three generations extending over the season, and the length of different stages varies at different times of the year. The adults hibernate under rubbish, in and near cowpea fields and gardens, and in clumps of rank grass. In the delta region clumps of *Andropogon virginicus* are favorite hibernating places, these dense clumps frequently growing

on a slight elevation and permitting the beetles to pass the winter above the general level of standing water in many places.

The beetles emerge from hibernation early in the spring. At Greenwood, Mississippi, this occurs about the first of April. On the Gulf Coast this occurs considerably earlier, and in the extreme southern part of this country they may not hibernate at all. On emergence they begin to feed chiefly upon garden beans and also what native food plants they can find. After feeding for a week or more, oviposition begins.

The eggs are placed in the ground within a few inches of the base of the plants and at varying depths. In loose soil they may be found within one-quarter of an inch of the surface, but the beetles frequently place them on the under side of clods of earth, in crevices, and between the base of the plant and the earth. They may in this way be placed a couple of inches below the general surface. Occasionally they are placed on the surface in damp shaded situations. Eggs have been found in clusters of from 1 to 49, the average size of a cluster being about 12. The eggs are of a deep yellow to orange color, elliptical, reticulate, and about .70 mm. long by .35 mm. in diameter. A single female has laid as many as 795 eggs, but the average is probably considerably less than this. Oviposition continues over a period of several weeks to a month. The eggs hatch in about 18 days in the spring, while in summer this period may be shortened to a week.

The larvæ at hatching are about 1.5 mm. long and when full-grown reach a length of 8–10 mm. At first they are of a creamy to a pale orange color, and the egg shells also retain the orange color after hatching. The larvæ later become pure white. The head, cervical shield, and anal shield are always black.

They feed upon the roots, root hairs, and root nodules. They can complete their growth on either roots or nodules, or both, but seem to prefer the latter when they are available. They cut off roots and devour a portion of a cut end and may gnaw some of the bark from a larger root. When attacking nodules they cut a round hole into the nodule and usually devour the entire contents, leaving only the outer shell. They usually crawl out through the entrance hole but may cut their way on through. Several small larvæ may attack a single nodule, making a number of entrance holes. One nodule has been found to contain as many as 8 young larvæ. The larvæ usually travel along the course of roots in search of fresh nodules, but may go short distances through the soil. They have been found to injure nodules as deep as 8 inches and over a foot in a horizontal direction from the base of the plant.

The larvæ pupate in a nearly upright position in small earthen cells

near the base of the plants or their horizontal roots and in depths varying from one-quarter of an inch to three inches. The depth of the pupal cells seems to be determined largely by the amount of moisture in the soil. During dry hot weather they pupate deeper than during wet weather.

The period of larval growth varies from about three weeks in mid-summer to six weeks or more in the fall. The pupal period extends over about four days in mid-summer and may be extended over two months in the fall. Pupæ have been found in the ground as late as the first week in January and these must have remained there in this stage since the first of November.

The first generation of adults appears about the middle of June. By this time practically all of the over-wintered beetles are dead. Oviposition for this brood extends practically into July and by this time the adults of the second generation begin to appear. A third brood begins to appear during the last of August and adults continue to emerge until stopped by cold weather in the fall, usually about the first of November. There is considerable overlapping of broods during the latter part of the season and there is probably a partial fourth brood.

Natural Enemies

Climatic conditions seem to be the principal natural check upon the multiplication of this insect. A rainy winter with occasional cold snaps undoubtedly results in a high mortality. In an experiment, under what seemed to be excellent conditions for hibernation, only 11 per cent of the beetles survived the winter. The character of the growing season also influences the rate of multiplication. A few beetles are killed by a fungus, probably *Sporotrichum*, and eggs in cages frequently become covered with a greenish mould and fail to hatch. A small reddish mite was found clinging to a recently hatched larva in a cage. Mr. G. G. Ainslie has noted that small mites apparently injured the eggs. Ants have been observed carrying off larvæ after they had been dug up. A Spring-tail, as yet undetermined, seems to kill pupæ when the ground becomes cold in the fall. The only internal parasite thus far reared is the Tachinid, *Celatoria diabroticæ*, which kills a small percentage of the beetles.

Damage

The amount of damage caused by the larvæ of the bean-leaf beetle is difficult to estimate. When the larvæ appear while the plants are young and before the nodules have developed, the roots suffer seriously. When the nodules have begun to develop the larvæ then attack them. Nodules appear first on the tap root and these are frequently all

destroyed before they are half grown. Later, nodules develop on lateral roots and nearly all of these may be found and destroyed when quite small. One larva is capable of destroying a considerable number of nodules. When the attack is delayed until the nodules have reached their full size, the destruction may be as complete but the damage is probably not as great. In any case a serious outbreak of the beetle means that the nodules have little opportunity for performing their function of collecting atmospheric nitrogen. This means that the plant will not be able through the nodules to store up nitrogen later to enrich the soil. While it is true that cowpeas will make a good growth in rich bottom soil irrespective of damage to the nodules, it is in the poorer hill soils that the loss of the nodules causes a marked decrease in the size of the plants, and it is in these soils deficient in nitrogen that the nitrogen-fixing ability of the nodules is most valuable.

A correct determination of the loss in this manner from the attacks of the larvæ involves a knowledge of the nodule-forming bacteria themselves and a chemical analysis of the plants. Consequently, coöperative experiments with the Bureau of Plant Industry have been arranged, and these are still in progress. For the present, an idea of the possibilities may be gained from what is known of the value of legumes in soil renovation. Mr. Lewis T. Leonard, of the Bureau of Plant Industry, who is in charge of the coöperative work on this insect, has kindly supplied a statement, as follows: "Professor Bottomley of England has estimated from German and United States reports that on an average the legume nodule adds 166 pounds of nitrogen per acre to the soil (166 pounds of nitrogen is equivalent to about 1,844 pounds of sodium nitrate)." He also has computed from reports in his office "that in the case of the cowpea the average value of the nodules to the plant is 140 per cent of the crop without the nodules, that is, by inoculation the crop is more than doubled." The importance of the loss of the nodules on a poor soil will readily be seen.

To this damage must also be added that caused by the larvæ to the roots. In addition it must be borne in mind that the adults are capable of destroying a stand of young cowpeas. Ordinarily, after cowpeas have made a good growth, the damage by the adults is not serious.

Suggestions for Control

The possibilities for the successful control of this insect on a crop of cowpeas are limited mainly to preventive measures. Since, as Weed first pointed out,[6] the first generation is in the main produced upon garden beans, it would appear that a campaign of thorough spraying with arsenicals against the adults as soon as they appear

upon beans would reduce their numbers considerably. Black-eyed peas, which are commonly grown in gardens in the south, should also be included, and wild host plants should be destroyed.

The date of planting a crop of cowpeas is also an important consideration. It has become a well established custom not to plant cowpeas until June. This custom has come about apparently from the ravages caused by this beetle on an early crop. It is important to dodge the first generation of beetles in order to allow the plants to make a good growth before the second generation appears and to allow the poisoning of the adults on beans to take place. This can probably be done in the latitude under consideration if peas are not sown earlier than the latter part of May.

There seemed to be a possibility of finding a resistant variety of cowpeas, and accordingly experiments were started to determine this point, the Bureau of Plant Industry furnishing the seed. This phase of the work is still being carried on, but it may be said that no variety is entirely immune. The Iron cowpea is damaged much less, both by larvæ and adults, than any variety so far experimented with. In view of the fact that it is also resistant to the root-knot disease, it promises well for the purpose of soil renovation wherever it is adapted to soil and climate.

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MR. F. M. WEBSTER: I only wish to point out the far-reaching results of these investigations. Following the idea put forward by Dr. Forbes last night, I think this furnishes an excellent illustration. We began twenty-eight years ago with the investigation of a beetle whose injuries were supposed to be restricted to the foliage of leguminous plants. Now we find ourselves at a point where we have to go to the ecologist, and the soil expert, as we find that the larvæ of this beetle in destroying these nitrogenous nodules, largely takes away the fertilizing value of these plants, especially if growing on the higher lands where there is the greatest need of additional fertility. And it takes us into a matter which the agronomist has overlooked.

Mr. McConnell has shown the actual financial value of these nodules to the farmer as compared with the cost of sodium nitrates.

PRESIDENT H. T. FERNALD: In the case of the papers remaining on the program, the authors are either absent or wish the papers presented by title.

At the close of this session, the regular business was transacted and the meeting adjourned at 11.30 a. m.

A New Pest, The Chrysanthemum Midge (*Rhopalomyia hypogaea* H. Lw.)

Specimens of badly infested chrysanthemum plants were received under date of March 27, 1915, from Prof. R. H. Pettit of the Michigan Agricultural College, accompanied by the statement that the above named insect, determined by the writer, was causing serious injury in the houses of a commercial chrysanthemum grower. Certain varieties, particularly mistletoe, appear to be very susceptible to injury. The plant submitted for examination had the stem from a point at about the surface of the ground to the region of the leaves, a distance of 1.5 cm., enlarged to practically twice the normal diameter, the swelling being composed of nearly approximate oval cells, each of these having a length of about 2 mm. Similar masses of infested tissue occurred in and near the midribs of the developing leaves and arrested the growth of the foliage, producing a close, ill-shaped head and the probable ruin of the plant for commercial purposes. A study of the midges and the deformities they produce convince us that this is an European species recorded from central and southern Europe as infesting *Chrysanthemum leucanthemum*, *C. corymbosum*, *C. atratum* and *C. japonicum*, and producing galls on the stalks, leaves, buds and presumably also on subterranean root stalks. The individual galls frequently form sub-conical projections from the swollen surface of the plant tissues.

This insect, like allied greenhouse species, probably breeds continuously when conditions are favorable, the initial attack being usually confined to buds (including the subterranean ones on root stalks) or tissues just unfolding from the buds. The midges transform in the gall and it is probable that hibernation or æstivation occurs either in the adult or possibly as larvæ in slowly developing, subterranean buds. The probabilities favor this insect being a serious local pest, since it has presumably become established in this country without its full complement of parasites. It is certainly desirable to ascertain the present distribution of the chrysanthemum midge in America, and growers of this popular flower would do well to adopt every reasonable precaution to keep their stock free from this insect. Badly infested plants should be burnt, and it is possible that, by cutting off and destroying infested portions of others, it may be practical to exterminate the insect in localities where it has become established without resort to more drastic measures. Fumigation with hydrocyanic acid gas, while deadly to the midges on the wing, would have little or no effect on the larvæ and could not be expected to accomplish more than prevent the insect from becoming excessively abundant.

E. P. FELT.

Proceedings of the Thirteenth Annual Meeting of the American Association of Official Horticultural Inspectors

(Papers continued)

IMPORTANT INSECT PESTS COLLECTED ON IMPORTED NURSERY STOCK IN 1914

By E. R. Sasscer

During the past year the Federal Horticultural Board has been issuing, from time to time, in the form of news letters, lists of insects and diseases intercepted on imported nursery stock by inspectors throughout the states. In preparing these lists an attempt has been made to present them in such a simplified manner as to be intelligible to the isolated inspector as well as to entomologists and pathologists. These news letters are not published, and the object of this contribution is to put on record the finding of certain injurious insects, some of which have not been listed in previous reports.

Fifty-one nests of the brown-tail moth (*Euproctis chrysorrhœa* Linn.) have been collected on French nursery stock, and three egg masses of the gipsy moth (*Porthetria dispar* Linn.) on cedar and camellia from Japan, and a single egg mass on azalea from Belgium. Larvæ of the pink boll worm (*Gelechia gossypiella* Saunders) were found in three shipments of Egyptian cotton, one of which exhibited a 20 per cent infestation and was to be forwarded to Arizona. This cotton pest is briefly described by Mr. W. D. Hunter in an unnumbered circular of the Bureau of Entomology, and, from all indications, would be a serious menace to the cotton industry if established in the southern states.

A single living adult of the olive fruit fly (*Dacus oleæ* Rossi) was discovered in a small package of olive seed from Cape Town, South Africa, after having been en route for 28 days. According to Silvestri, it requires from 47 to 49 days in Italy for the pupa to transform to the adult, and it is possible, therefore, for this pest to enter the United States through eastern ports of entry and still have ample time to reach the olive-growing sections of California prior to the emergence of the adult. In addition to the olive fruit fly, a dead specimen of what appeared to be *Dacus semispharens* (Becker) was found in the same small package.

Avocado seed from Guatemala were infested with the larvæ of an undescribed curculio (*Conotrachelus* sp.). The number of larvæ per seed varied from one to five, and the injury occasioned is not unlike

that of the avocado weevil (*Heilipus lauri* Boh.). These seed were also infested with the broad-nosed grain weevil (*Carpophilus latinasus* Say).

A single specimen of the banana root borer (*Sphenophorus sordidus* Germ.) was found in a banana plant held in quarantine from Brazil. When received the plant was apparently healthy, but, after remaining in quarantine for several months, it commenced to die down, and, on close examination, the roots were found to be riddled by the larva mentioned. According to Jepson[1] this insect is a serious pest to banana plantations in the Fiji Islands, and no variety seems immune from its attacks.

Egg masses of the European tussock or vapourer moth (*Notolophus antiqua* Linn.) have been frequently taken on various kinds of stock from Denmark, Holland, France, and Belgium. According to English writers, this insect is somewhat partial to civilized life, and frequents trees in densely populated cities, gardens, and parks. At times it is responsible for considerable damage to roses and to fruit and forest trees.

Cocoons of the Oriental Moth (*Cnidocampa flavescens* Walk.) were found on Japanese stock. This insect has an extensive distribution in the Orient, and has previously been introduced into this country. A full account of this pest is given by Dr. H. T. Fernald in Bulletin No. 114, Hatch Experiment Station of the Massachusetts Agricultural College (1907).

The citrus leaf miner (*Phyllocnistis citrella* Stainton) has been detected on Citrus and Atalantia from the Philippine Islands. According to Mr. R. S. Woglum[2] this leaf miner is a serious pest in India, and is especially injurious to citrus nursery stock.

Puparia of the papaya fruit fly (*Toxotrypana curvicauda* Gerst.) were received in a package containing an unknown vine from Mexico. This material was retained, and subsequently adults were reared. An account of this fruit fly was recently given by Messrs. Knab and Yothers.[3]

Coccids have been reported frequently, some of the more important of which are the following:

Aspidiotus destructor (Sign.) on *Mangifera verticillata*, *M. indica* var. *carabao*, *Eugenia* sp. from the Philippine Islands, and cocoanut from American Samoa.

Chionaspis wistariæ (Cooley) on Wistaria from Japan.

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[1] "Report on Economic Entomology," Department of Agriculture, Fiji, Council Paper No. 25, p. 48, 1911.

[2] Bull. No. 120, Bureau of Entomology, U. S. Department of Agriculture, p. 49 (1913).

[3] Journal of Agricultural Research, II, 6, p. 447 (1914).

Epidiaspis pyricola (Del Guer.) on pear seedlings from France.
Morganella maskelli (Ckll.) on Citrus from Java and Brazil.
Targionia biformis (Ckll.) on orchids from Venezuela and Colombia.
Odonaspis secreta (Ckll.) on bamboo from Japan.
Odonaspis sp. on grass from Brazil.
Parlatoria sp. on Mango and Citrus from Brazil.
Pseudaonidia articulatus (Morg.) on Limoncillo from Ecuador, and on Cinnamon from Colombia.
Pseudaonidia duplex (Ckll.) on Camellia, Persimmon, and tea trees from Japan.
Pseudaonidia paoniæ (Ckll.) on Azalea, Camellia, Pear, Gardenia, *Olea fragrans*, and Andromedas from Japan.
Pseudaonidia trilobitiformis (Green) on *Jaboticaba murta* from Brazil and Citrus from Japan.
Pseudococcus ryani (Coq.) on *Sciadopitys verticillata* from Japan.
Pseudococcus calceolariæ (Mask.) on sugar cane from Brazil and flax from New Zealand.

The following list indicates by countries the number of species of insects collected on imported stock and reported to the Federal Horticultural Board by various State and Federal inspectors:

Algeria, 3.
Argentine, 2.
Australia, 7.
Belgian Congo, 1.
Belgium, 53.
Bermuda, 3.
Bolivia, 1.
Brazil, 50.
Canada, 2.
Canal Zone, 3.
Cape Colony, 2.
Ceylon, 1.
China, 13.
Colombia, 37.
Costa Rica, 7.
Cuba, 2.
Denmark, 2.
Ecuador, 4.
Egypt, 6.
England, 22.
Formosa, 2.
France, 35.
Germany, 5.
Guatemala, 13.
British Guiana, 1.
Hawaii, 1.
Holland, 58.
India, 10.
Ireland, 1.
Italy, 2.
Japan, 67.
Java, 9.
Kamerun, 3.
Korea, 1.
Mexico, 9.
New Zealand, 14.
Nigeria, 11.
Palestine, 1.
Paraguay, 1.
Peru, 1.
Philippine Islands, 24.
Reunion, 1.
Samoa, 7.
Siam, 3.
Sudan (Africa), 1.
Trinidad, 4.
Transvaal (So. Africa), 3.
Turkey, 1.
Venezuela, 3.

THE PREVENTION OF RABBIT INJURY TO YOUNG APPLE TREES

By E. N. Cory, *College Park, Md.*

(*Abstract*)

Economic entomologists are frequently asked to lend their services in preventing or controlling animal pests, that do not belong to the insect world. Such a request was made of the Department of Entomology in Maryland in December, 1913, the animal pests in question being cotton-tail rabbits (*Lepus sylvaticus*). They were reported as having badly cut the trunks of young apple trees planted on the

mountain sides. Some of the blocks of one- and two-year trees had suffered injury to the extent of 95 per cent of the entire stock. In other places the rabbits had not begun to work.

Electric welded wire screen of one-fourth inch mesh, 18″×10″, had been used in many of the orchards with success at a cost of one-half cent per tree, where the wire was bought by the carload, plus labor cost. Various washes of fish oil soap, blood, glue, hair, lime, and other ingredients had been used with little or no success. White lead and raw linseed oil in the proportion of ¾ part lead to ¼ part oil had been used on a large number of trees. This cost approximately three-fourth cent per tree, labor being one-fifth cent per tree. The rabbits gnawed through this covering in most instances.

The writer visited the place and demonstrated the preparation of concentrated lime sulphur and the method of thickening the material for brushing on the trees. Some commercial lime sulphur was used. About 600,000 one- and two-year apple trees were treated.

The lime sulphur was diluted at the rate of 1 to 9 and approximately 30 pounds of stone lime used to each 50 gallons of the diluted wash to thicken it. Five gallons of lime sulphur was placed in a barrel and stone lime gradually added and slaked in it. This tended to combine any free sulphur that remained. Water was gradually added, as needed to prevent burning and at the conclusion of the slaking to make up the wash to 50 gallons, thus giving a thickened wash of lime sulphur at a dilution of 1 to 9. Other lots were made up by first slaking the lime in large quantities, and adding the milk of lime to the diluted lime sulphur.

This material was applied by gangs of men, each of whom was supplied with a gallon bucket and a three-inch varnish brush. Each man was able to cover about 700 trees per day at a cost of one-fifth cent per tree for labor and slightly over one-sixth cent per tree for material.

The material proved very successful and the most economical wash that can be used on a large orchard.

THE ESSENTIALS OF INSECT CONTROL

By Thomas J. Headlee, Ph.D., *State Entomologist of New Jersey*

Introduction

It is purposed to treat this subject briefly from the standpoint of the insect control official. It is understood that all consideration of experimental studies so necessary to carrying on the control official's work will be disregarded and attention centered on the routine work of preventing insect pests in other states and in foreign lands from be-

coming established within the control official's territory, and of preventing insects already established within his territory from assuming the character of serious pests.

Preventing Injurious Insects and Diseases from Becoming Established

Control officials are in substantial agreement that for preventing undesirable insects from becoming established it is necessary to close the channels through which they naturally enter. Differences of opinion and practice obtain relative to the methods of closing these channels. Some officials require merely that all nursery stock shall come in under a regular certificate of inspection, totally ignoring the fact that the certificate may mean much or little. Others require the certificate and attempt also to determine to some extent the character of the person or firm shipping goods into the protected territory. Others require the certificate, inspect a certain percentage of the stock and do or do not examine the standing of the shipper. Still others examine all stock shipped in.

Examination of the various insect control laws shows conclusively that the practice of depending on the certificate is considered unsafe by many of the control officials. Indeed, the various discussions of the nursery certificate, which consume a part of the time of this association practically every year, serve to show that dependence upon the certificate as a means of preventing injurious insects and diseases from entering the control official's territory is dangerous. Many attempts have been made to better the certificate by making it state more specifically what it means.

Doubt exists in the mind of the writer whether the attempt to make the certificate more specific is really worth while in view of the fact that such action is almost certain to increase the length of that already in use or multiply the kinds used. Certificates are already as long as will readily go on a shipping tag of convenient size, and any increase in length is for that reason undesirable. The multiplication in type means confusion to the agents of the common carrier and, to some extent, both to consignor and consignee. A certificate properly dated and signed is a certificate to the common carrier's agent and, speaking generally, to the consignee. Further addition to the burdens of the carrier's agents is likely to bring about disregard for the control official's requirements. Furthermore, the consignee takes the certificate to mean that the stock is not only free from the specified San José scale and black-rot canker but from all seriously injurious insects and plant diseases. The control official cannot escape responsibility for the other parasites a given shipment may have by specifying the

troubles it may be free from. The certificate means to the consignee a clean bill of health, and the moral responsibility of the control official is not effectually minimized by specifying the particular pests from which the stock is free.

That it is desirable for the control official to know just what the certificate means should be granted without argument; but may this not be obtained without either lengthening the present certificate or multiplying the type? At each of the last three meetings of this association, it has been suggested in a more or less official way that information relative to the species of insects which are held by him to be seriously injurious should be collected from every control official and that this information should be printed and distributed among the control officials of the United States. It is the writer's remembrance that a committee was appointed to confer with the Federal Horticultural Board relative to the matter and to induce the board to prepare such a publication. It seems sufficient to say that, regardless of the action taken, no such publication has ever been distributed.

The attempt to bring about the more complete closing of the channels through which pests penetrate the protected territory, by investigating the responsibility of the consignor in addition to requiring the regular certificate is full of difficulties and would seem to offer little protection. Its influence is almost entirely moral and, if unaccompanied by examination of a part, at least, of the incoming stock, can be expected to affect only the weak and the strictly honest. As the members of this association are perfectly aware, there is a common distinction between personal and business honesty. In using the term "strictly honest" the writer refers to the business conducted from the standpoint of personal honesty. In so far as this investigation of the consignor results in keeping close track of the incoming shipments the results are bound to be good.

The attempt to prevent the introduction of undesirable insects, by requiring the consignor to furnish prompt information of each shipment in addition to covering each by a regular certificate accompanied by inspection of a considerable percentage of the stock received, is the best method thus far developed when the funds have been limited. By such an arrangement the consignor knows that any one of his shipments may be examined and that should any be found infested he will be subjected to the closest possible scrutiny and the purchase of his stock, perhaps, advised against. He is thereby almost if not quite as effectually deterred from knowingly shipping infested stock as he would be by universal inspection. The attempt to keep track of incoming stock by requiring the common carrier to notify the control official is an unsatisfactory method from the standpoint of practical

inspection, because it usually does not give the inspector proper basis for judging the importance of the shipment.

The attempt to prevent the importation of seriously injurious insects by examining all incoming stock is theoretically the best method possible. By it the chance of an injurious species obtaining foothold would seem to be reduced to its lowest terms. As a matter of fact, it is a question in the writer's mind whether the difficulty in choosing and managing the large group of inspectors necessary does not counterbalance the advantage gained by complete inspection: whether therefore the partial inspection carried out by a small number of capable men, who, because of their small number can be more carefully chosen and better paid, does not afford as great a degree of protection as that given by the complete inspection.

The work of preventing insect pests of foreign countries from entering protected territory has only been recently undertaken. The discovery of brown-tail moth nests on pear stock from France apparently first roused the control officials of this country to the necessity of examining foreign stock. The fear of the introduction of the brown-tail and gipsy moths in this manner was so great and the volume of foreign stock likely to bring these pests so small that a large proportion of the shipments was examined. The creation of the Federal Horticultural Board, which followed the realization of this danger, brought into existence a much-needed agency for the control of the interstate and foreign shipments. This body has served the cause of insect control well by closing the mails to unexamined plants, by so organizing the importations that practically all shipments are examined, and by quarantining areas of infestation from which exceedingly dangerous insects are likely to come.

It is well to observe, however, in spite of all of these agencies for preventing insect spread that little by little many injurious species are widening their distribution, and that, as the writer stated in a former paper[1] it is probably only a matter of time until their range throughout the world will include all regions where food conditions are favorable and climate bearable. The delay in their distribution which it seems practicable to effect through control measures seems likely to prove sufficient for their new environment to become adapted to them, and for the natural enemies, which attack them in their old homes, to become distributed in their new ones, thereby reducing them to the position of the pests native to the country into which they have migrated before they have had a chance to do great damage.

In New Jersey the control officials do not desire a change in the wording of the nursery certificate or to have the consignor commit himself

[1] JOURNAL OF ECONOMIC ENTOMOLOGY, Vol. VI, pp. 130–133.

by any personal promise. They want a knowledge of what the certificates of the various control officials mean, to have information of what is being consigned to persons or firms doing business in the state, and to examine a considerable percentage of the total amount coming in. Of course, it is their desire to examine all stock coming in under a certificate with the meaning of which they are not familiar, all entering under a permit not backed by adequate inspection, and all which comes from regions infested with exceptionally injurious forms.

Preventing Outbreaks of Already Established Insects

Basing his opinion upon the insect and plant disease control laws now in force in the different states and upon his experience in enforcing laws of this sort in two different states, it seems to the writer that the work of preventing the establishment of seriously injurious insects is far more effectively done than is the work of controlling the outbreaks of already well-established species. Year out and year in the standard pests of the country gather headway in some parts of their range and do large damage. Sometimes the coming outbreak is foreseen and adequate preparations made to meet it, but rarely is this so. There are certain great difficulties in the way of handling this problem in an efficient manner. The first of these is the securing of adequate information as to the abundance of the obscure stages in different parts of the area. The second is found in interpreting such data as may be collected. The third is the placing of this information before the public in such a fashion that the persons who should have it, will get it and act upon it.

The problem of determining the abundance of the pest can be solved only by extensive and continuous scrutiny—that type of scrutiny which will keep the control official informed the year round as to just what each stage of each pest is doing and how much above the normal the existing density of the infestation is. A few control officials practice this regular and satisfactory method of obtaining information to some extent, but the number doing it is small and those that do make use of it rarely attempt to cover the whole field.

The problem of interpreting the data thus gathered is difficult, partly because the data of the findings and the results during the growing season of previous years are not only meagre but not organized in such a fashion as to render them available and partly because the effect of natural enemy and of weather conditions is too poorly understood. We need the accumulation of experience along these lines that comes only as the result of well-directed effort. The control officials should begin this accumulation and the attention of experimentalists should be drawn to this field of entomological work.

The problem of laying this information before the persons concerned in a really effective fashion (that fashion which will produce effective action) is not by any means easy, but it seems to the writer less difficult than the other two. With laws sufficiently powerful and proper organization of the people who are to be protected, the adequate sort of action could be secured.

Conclusions

It is the writer's strong conviction that the most efficient protection of the control official's territory will not come through increasing the complexity of certification but rather through that coöperation of control officials which will give the information sought without increase in red tape.

It is further the writer's belief that in its last analysis, the efficient protection of the territory depends upon the more or less complete examination of stock coming into it and that a very valuable prerequisite is advance information of the source, nature, extent, destination, probable date of arrival, and consignee of each of the various shipments.

It is also the writer's conviction that the prevention of the establishment of new pests is far more effective than is the control of outbreaks of insects already established, and that the time is at hand when a more satisfactory reduction of the latter must be effected.

[*Papers read by title*]

NOTES ON THE ONION MAGGOT IN 1914

By A. I. Bourne, A.B., *Massachusetts Agricultural College*

In any treatment of the season's work against the onion maggot, reference should be made to the general climatic conditions prevailing in the spring of 1914, in so far as they had any bearing upon the experiments undertaken.

The early spring in Massachusetts and especially in the Connecticut Valley was in many respects unusual. Following a winter in which were several intervals of very severe cold, there was a long period of cold, rainy weather which continued well through April and into May. This handicapped the farmer to a considerable extent, for except in especially favorable locations, the land was in no condition to be worked until very late, and so planting was much delayed. The experimental plots could not be handled until fully three weeks later than in the previous year, and at least two weeks later than in 1912. As a result, at the time when normally the onion flies begin to make their appearance in the field to deposit their eggs on young plants, these plants were

either just breaking through the ground or were not yet in sight. The field work, therefore, was begun much later than before and ran until late in the summer.

Upon frequent examinations, it was soon observed that the infestation was very slight compared with former years. Inquiry revealed that this was noticed quite generally by onion growers in this region. Along with this fact may be noted that two other very common pests, the Colorado potato beetle and the squash bug, were also conspicuous for their relative scarcity of numbers. Whether there was any direct connection between the winter with its periods of severe cold, the late spring season and this marked scarcity of these common pests which normally occur in approximately the same relative abundance from year to year, or whether it was merely a curious coincidence, it is hard to determine.

The season's work was planned in general to follow out the lines begun the previous year, to corroborate the results of that season's work, and secure additional data as to details of manipulation of the various materials used.

Previous work had demonstrated clearly that remedies and methods usually recommended for the control of the onion fly were out of the question for use in large fields, both because of the initial cost of the substances themselves, and the great expense for labor necessary to prepare and apply them. Furthermore, most if not all of them depended for the protection they gave, upon frequent renewals, all of which made their expense mount up to a prohibitive figure. In fact, their cost would often be higher than the loss caused by maggots, if no treatment other than pulling out infested plants during weeding were given.

Therefore some method of applying treatment at the same time, or in connection with planting, seemed to offer the best chance of success. This was taken up in 1913, as reported in the April number of the JOURNAL OF ECONOMIC ENTOMOLOGY for 1914. The results of that season demonstrated that several of the materials used were of so little value that further work with them was impracticable. In this class were naphthalene, soluble sulphur, powdered tansy, oil of tansy, etc. Some of these were out of the question because of cost and difficulty of securing in large quantities, and some had a decidedly injurious effect upon the growth of the onion. This was true especially of naphthalene. It appeared to control the maggots but at the same time seemed to prevent germination to a large extent. Other substances did not appear to have any effect upon either the plants or the maggots, at least when used in quantities practicable from the standpoint of expense.

Germination tests carried on during the winter furnished some further light upon the relative values of the different materials.

In the field experiments, only those materials which from the previous year had appeared of value, were given a trial. The method of application followed was that of using an ordinary onion planter with the covering wheel removed. This left the seed uncovered in the rows. The different substances were then applied on top of the seed and the rows covered by hand. This manual work was necessary from the fact that it was impossible to secure a machine with the supply tank behind the seed dropper, and for several reasons the alterations could not be made in time.

It was evident that the plants in rows which had been treated were retarded to some extent in their early growth, as compared to those in untreated or check rows. This caused the plants in treated rows to appear above ground a few days later than in check rows, but as the season progressed they apparently recovered from the slight early check and in the latter part of the summer there was very little, if any, difference apparent.

As mentioned above, the naphthalene, when used alone, had a decidedly injurious effect upon the germination and caused a very irregular "stand." However, when diluted by mixing with a substance less powerful as a repelling agent, it appeared safe and warranted a continuance of its use in the experiments.

The scarcity of maggots in the experimental plots was very pronounced. There were fewer infested plants found in both plots on check and treated rows combined, than in former years had been found in the check rows of one plot alone. In fact, the total number during all the present season was less than one-half those found in 1913 in the check rows of one plot. The number of check rows was the same for both years.

This extremely light infestation at first gave rise to some doubts as to the possibility of securing anything like trustworthy data. The results that were obtained, however, from the whole season's records, bore out in general those of the previous years, although on a smaller scale, due to the meagre numbers of the maggots found.

The degree of protection given by the different treatments was approximately the same as before. This was also true in the relative abundance of maggots in check and treated rows, so that although the totals were much smaller, their relative standing agreed with those of the previous year.

It was very evident that for the successful working out of this plan of applying treatment at the time of planting, a special design of planter would be required. A machine was purchased which seemed

to fit nearest the type desired. Several necessary changes were made, however, such as placing the feed or fertilizer tank so as to allow its emptying behind the seed dropper, together with other alterations, being careful all the while to keep the whole weight so well balanced as to allow smooth running in the field and avoid clogging the seed dropper, while still allowing enough weight on the covering wheel to cause it to cover the soil over the rows and roll it down evenly. Considerable time was given to this, and the aid of a high rate mechanic employed to make the necessary changes. Circumstances prevented its completion and use during the present season, but in its employment another year it is hoped that several of the factors of variation entering into the problem may be eliminated and thus enable the securing of more reliable data as to the relative value of the different treatments, based on their effectiveness against attack.

THE APPLE FLEA-WEEVIL IN ILLINOIS

Orchestes canus

By P. A. GLENN, *Urbana, Ill.*

In June, 1901, a small black rhynchophorous beetle was discovered at several points in southern Illinois feeding upon the foliage of apple, causing in some instances considerable damage. The species was at first supposed to be *Orchestes pallicornis* Say, but was later ascertained to be *Orchestes canus* Horn. This species was described by Dr. G. H. Horn in 1873 from specimens of adults from Michigan and Colorado. So far as we have been able to learn, there is no further reference to it in entomological literature until 1901, when the first published account of its injurious habits appeared under the title "A New Apple Insect," in a paper read by Dr. S. A. Forbes before the Illinois State Horticultural Society and published in the Transactions of that society for the year 1901. A more extended illustrated article, prepared by Mr. Charles A. Hart, was published in 1911 in the Twenty-Sixth Report of the State Entomologist of Illinois. A paper entitled "The Apple Flea-weevil in Illinois," by Stephen A. Forbes, was published in 1912 in Volume 46, New Series, of the Transactions of the Illinois State Horticultural Society, and another paper entitled "The Apple Flea-weevil," prepared by the writer, was published in 1913 in Volume 47 of the Transactions of the same society.

GENERAL DESCRIPTION OF STAGES

The adult of the apple flea-weevil is about one-eighth of an inch long, rather robust, and of a uniform dull black color throughout. The eyes are large, almost meeting in front, and the beak is only slightly

curved and rather stout. The posterior legs are fitted for jumping, the hind femur being enlarged. When disturbed, the beetle either jumps or drops to the ground and feigns death.

The egg, which is deposited in the veins of the leaves, is smooth, yellowish in color, rather bluntly rounded at the ends, and slightly curved.

The larva is flat, yellow in color, and about three-sixteenths of an inch in length when full-grown. The segments of the body are distinctly marked. The body is much wider and more bluntly rounded anteriorly than posteriorly, the segments after the sixth decreasing gradually in width, the last segment being very narrow and ending in a rather acute point.

The pupa is white and resembles other rhynchophorous pupæ of nearly related genera.

History in Illinois

It was first found injurious to the apple at various points in southern Illinois in June, 1901, by Messrs. E. S. G. Titus and Charles A. Hart, who were at that time, as Dr. S. A. Forbes's assistants, making a study of apple insects in that part of the state. It was again found by Mr. Titus the following spring and by Mr. E. P. Taylor throughout the same region in 1905, and by Mr. Hart in western Illinois in 1906. The following is quoted from Mr. Hart's article in the Twenty-Sixth Report of the Illinois State Entomologist: "In Illinois we have seen it or its characteristic injuries at about thirty different towns: In Pulaski, Union, Jackson and Williamson counties in extreme southern Illinois; in the prairie fruit region of Washington, Jefferson, Marion, Clay, Wayne, Edwards and Richland counties; in Jersey, Calhoun and Pike counties in the western part of the state; and in Coles and Christian counties in south-central Illinois. It is represented in our collections by several specimens labeled 'N. Ill.,' and by one from Normal, McLean county; and it will probably be found to infest apple trees throughout the state."

During the last three years it has been more or less abundant in all the southern and western counties above recorded. In some localities the beetles were abundant enough to be of considerable economic interest and injuries have been quite serious, especially in orchards in which the foliage was scanty.

Character and Extent of Injury

The injury is caused both by the larvæ which work as miners in the leaves, and by the adults which feed upon the leaves. The injury caused by the larvæ is very much less serious than that caused by the beetles, but frequently the mines are so plentiful that nearly every

leaf on the tree contains one or more. The beetles in feeding work on the under sides of the leaves and eat out the soft tissues between the veinlets, leaving the epidermis of the upper surface of the leaf uninjured. The pits thus made by them are from one-half to one millimeter in diameter, and a number of them are usually made together, being separated only by the veinlets, which are left uninjured. Badly injured leaves present a sieve-like appearance when viewed from beneath. A single beetle confined for several days on fresh leaves made an average of nine such feeding-pits a day. Since the number of beetles on a tree frequently equals the number of leaves, it will readily be seen that they are capable of becoming a very serious pest. The injury, however, is usually not very serious, but varies greatly in different localities and in different seasons. The reduction of leaf surface caused by the beetles varies from a fraction of 1 per cent to 50 per cent or more, of the entire leaf surface. A reduction of 50, or even 25 per cent of the leaf surface in this way is a very serious injury, since it not only deprives the tree of a large per cent of its food elaborating tissues, but the removal of the epidermis of the lower surface in so many places exposes the soft tissues of the leaf to the drying effects of the atmosphere, and to the injurious action of spray mixtures, and opens the way for the entrance of the spores of injurious fungous diseases, resulting usually in the total loss of badly infested leaves.

Life-History and Habits

The insect is single-brooded. The winter is passed by the adult among leaves and grass and under clods or in cracks in the ground, under and near trees which they infest in orchards or woodlands. These hibernating adults become active in spring as soon as the frost is out of the ground, or about the last week in March in the latitude of St. Louis; and ascend to the branches, there to await the appearance of the leaves. As soon as the leaves appear they begin to feed on them, and by the middle of April or a little later, begin to deposit eggs. The eggs are deposited in the large veins of the leaves, in longitudinal cavities gnawed out from the under side by the female. Egg-laying continues for about a month, or to about the middle of May, after which time the adults soon die. The egg hatches in four or five days and the larva as it feeds constructs a mine extending toward the edge and usually towards the tip of the leaf. When the edge of the leaf is reached the mine becomes a blotch-mine. The larva matures in about three weeks and constructs within the mine a sort of cocoon, within which it pupates, and from which a few days later the adult beetle emerges. These mines when fully developed are brick red in color and are quite conspicuous. As a result of the wound made by

the female in depositing the egg, a swelling is produced in the vein at the point where the incision was made, causing the vein to angle upward slightly at this point. The new generation of adults begin to emerge about the middle of May, and continues to emerge till the second week in June, and are to be found during the latter part of May and the whole of June feeding on the foliage of apple and nearly related trees in orchards and woodlands. By the latter part of June they begin to descend to the ground and hide away among the leaves and grass, and in the soil, where they remain for the rest of the season, apparently without food, and during the following winter, to reappear in spring. By the end of the first week in July all the beetles have disappeared from the trees. These adults are quite active during the month of June, and may be seen flying from tree to tree in the orchards. For the rest of the season they remain dormant. When a leaf upon which a beetle is resting is disturbed the beetle usually falls to the ground and feigns death.

Food Plants

Larval mines have been found in the leaves of apple, crab-apple, and cratægus. The adult beetles feed upon the leaves of apple, crab-apple, cratægus, wild cherry, and choke cherry, and an occasional feeding puncture has been found on leaves of pear trees growing in apple orchards. When confined in a cage on pear leaves, they will feed freely on them but will not deposit eggs in the veins. The adults of the new spring generation evidently fly about considerably, since they are to be found throughout woodlands, near infested orchards wherever the trees above mentioned are found.

Control Measures

The serious injury caused by this insect in some localities during the spring of 1913 made it seem advisable to devise some means of controlling it, and the writer was selected for this work. Experiments began June 10, 1913. At this time the hibernating beetles had disappeared and the adults of the new generation were feeding on the foliage in large numbers. The work was continued the following spring, beginning early before the hibernating beetles had emerged from their winter quarters. The results of the experiments may be briefly summarized under the following heads: Sticky bands, arsenical sprays, and contact sprays.

Sticky Bands.—At the time when the experiments began many beetles were seen crawling up and down the trunks of the trees. A number of trees in a badly infested orchard at Newton, Ill., were banded with tanglefoot, with the expectation that many of the beetles

would be trapped in this way. Five days later an average of 423 beetles was found on these bands. Two such bands were placed on the trunks of several trees, and in three days an average of 656 beetles to the tree had been caught. The following spring 64 trees in this same orchard were banded early before the beetles had emerged from their winter quarters, in the hope that they might be caught in large numbers while ascending the trees. The first beetles to emerge in spring were rather sluggish and attempted to reach the branches of the tree by crawling up the trunk, but later when the weather became warmer, many of them flew directly from the ground to the branches, with the result that while the beetles which attempted to crawl up the trunk of the trees were prevented from doing so, and many of them were caught in the bands, others succeeded in getting past the bands by flying. Many beetles crawling up the trunks of the trees were observed to take wing and again alight on the trunk, and others flying from the ground were also observed to alight on the trunk. Some of these alighted on the bands and were unable to extricate themselves; a large proportion of the beetles which were caught in the bands were caught in this way, and for this reason the wider the bands were the greater was the number of beetles caught. It was estimated that bands from three to five inches wide placed about the trunks of trees reduced the number of larval mines in the leaves of the banded trees about 50 per cent. Wider bands would be more effective but also more expensive, and it is doubtful if it pays to go to the trouble and expense of using a protective measure whose efficiency is only 50 per cent.

Arsenical Sprays.—Since the larvæ of this species are leaf-miners, there is no way of reaching them with arsenical sprays; but the adults feed upon the tissues of the under side of the leaves and hence arsenical sprays applied so as to cover the under sides of the leaves should theoretically be effective. Sprayed orchards, however, have suffered almost as badly as unsprayed ones. This fact may possibly be explained in several ways: viz., the beetles may be less susceptible to poison sprays than other insects that are easily controlled by them; the beetles may possibly be able to discriminate between poisoned leaves and those not poisoned, and in this way avoid the poison; the spray may not have been applied so as to cover thoroughly enough the under sides of the leaves where the beetles feed; and lastly, the sprays may not have been applied at the proper time.

By inclosing beetles in a cage with poisoned leaves it was found that when they fed freely some died within a day or two while others lived for a week or more, indicating that while they are not immune from poisons, some are much less susceptible to poison than others, or else feed less freely upon poisoned tissues.

By confining beetles in a cage containing unsprayed leaves, and also leaves sprayed with various combinations such as arsenate of lead and water; arsenate of lead, water, and flour paste; arsenate of lead and soap; lime-sulphur; and Bordeaux mixture; it was found that the beetles fed much more freely on the unsprayed leaves than on those sprayed with mixtures containing either soap, lime-sulphur, or Bordeaux. Leaves sprayed with the arsenate of lead and water and with arsenate of lead, water and flour paste were eaten nearly as freely as the unsprayed leaves. It is probable, therefore, that the addition of lime-sulphur or Bordeaux mixture to an arsenical spray renders it ineffective, since they are both distasteful to the beetle and help it to avoid the poisoned leaves. Later observations tend to confirm this conclusion. This last spring the writer was in an orchard where the flea-beetles were very numerous. The owner of this orchard had sprayed several rows of trees with arsenate of lead and water, and several adjoining rows with arsenate of lead and Bordeaux. Two days later dead beetles were lying thick on the ground under the trees sprayed with the arsenate of lead and water, but hardly any could be found under the trees in the rows sprayed with arsenate of lead and Bordeaux. The spraying in this case had all been done the same day, the spray applied in the same manner in both cases, and the beetles were equally abundant in all the rows at the time the spraying was done. The difference in results must therefore have been due to the fact that Bordeaux was used in one case and not in the other.

The beetles' habit of feeding almost exclusively on the under sides of the leaves suggests the necessity of directing the spray upward, rather than downward or horizontally as is usually done, especially early in spring. In the spraying mentioned above, special care was taken to cover the lower sides of the leaves, and the large number of beetles poisoned in the one case is evidence that this method of spraying is quite effective.

In one experiment 24 trees were sprayed with arsenate of lead, 4 pounds; flour (made into a smooth paste by scalding), 8 pounds; and water, 100 gallons. The spray was directed upward so as to cover thoroughly the under sides of the leaves, no attention being paid to the upper sides, with a pressure of about 150 pounds per square inch. Two days later dead beetles were lying thick on the ground. On a canvas about 90 square feet in area, which was spread under one of these trees as soon as the spraying was completed, 720 dead beetles were found two days later. It was estimated that an average of over 3,000 beetles to the tree had been poisoned in this way, and that this number represented between 70 and 80 per cent of the beetles on the trees before spraying began. These results also indicate that the

method of applying the spray so as to cover the under sides of the leaves is at least moderately effective.

In order to determine the proper time to spray, one has only to recall the seasonal history of the species. The beetles feed upon the leaves of the trees about two weeks before egg-laying begins to any extent. Egg-laying begins shortly before the trees come into bloom, and continues for about four weeks. Spraying should therefore be begun before the trees are in bloom, in order to destroy the beetles before eggs for the new generation are deposited. If spraying with arsenicals is delayed until after the petals fall, a large proportion of the eggs will have been deposited and no amount of spraying at this time or later can prevent the development of the larvæ and the final emergence of the adults of the new generation.

The adults of the new generation are to be found on the trees throughout June, hence spraying to destroy these and so prevent them from injuring the foliage should begin about the first week in June.

Many orchard men do not use an arsenical spray before trees are in bloom and hence, for this reason alone if for no other, spraying has proven ineffective so far as the development of the new spring generation is concerned.

It appears, therefore, that the apparent ineffectiveness of arsenical sprays has been in a measure at least due to each of the four causes above mentioned, and it seems very probable that by the observance of the following suggestions satisfactory results will be secured: 1. Increase the amount of arsenate of lead to 3 pounds of the paste to 100 gallons; 2. Omit the fungicide from the arsenical spray when spraying to control the apple flea-weevil; 3. Spray with a pressure of 200 pounds or more, and direct the spray so as to cover the entire leaf surface; and 4. Begin spraying while the fruit is in the cluster-bud stage, spray again after the majority of the new generation of beetles have emerged, and, if necessary, follow this spraying with another as soon as possible.

Contact Sprays.—In the early experiments it was found that the beetles are very easily killed with kerosene emulsion and nicotine sprays, the only difficulty being in getting the spray on them in sufficient quantities. To accomplish this two large canvases were made, each 15 by 30 feet. These were spread beneath the trees while they were being sprayed. The spray was driven under a pressure of 200 pounds or more to the square inch, and directed upward so as to strike the under sides of the leaves. As soon as the spray strikes the leaves the beetles fall to the canvas, where they are killed by the kerosene. A 5 per cent emulsion is fairly effective, but a 7 per cent emulsion works much better. Black-leaf-40, at the rate of 1 pint to 100 gallons of

water, is about as effective as an emulsion containing 5 per cent kerosene. This method works well when the trees are not too large and the branches are trimmed up so that the canvases can be operated without obstruction, but in orchards in which the trees are large, and the lower limbs are so low that their tips rest on the ground, it is very difficult to spray thoroughly and to manipulate the canvases expeditiously. The canvases used were made of heavy unbleached muslin. Strips were nailed across the ends of each to facilitate the handling of them. One by taking hold of one of these strips can drag the canvas from one tree to another, and in this way two men or boys can move the canvases from one tree to another about as quickly as they can walk the distance.

This method of combating the apple flea-weevil has the advantage of giving immediate results, and of giving the orchardist the satisfaction of seeing the beetles lying dead on the canvas at his feet as soon as spraying has been completed. It has the disadvantage, however, of requiring an extra application for which the apple grower has little time to spare, and hence will probably not be employed extensively except as a last resort to reduce the number of beetles of the new generation in June when earlier treatment has failed to suppress them.

Fortunately, it is only occasionally that this insect becomes troublesome, and when it does, the apple grower will doubtless be able to control it by making such alterations in his usual program and methods of spraying with arsenicals as to adapt them to its peculiarities.

AN OUTBREAK OF THE ALFALFA LOOPER

(*Autographa gamma californica* Speyer)

By J. R. Parker, *Assistant Entomologist, Montana Experiment Station, Bozeman, Montana*

The most striking entomological feature of the season of 1914 in Montana was an outbreak of the alfalfa looper (*Autographa gamma californica* Speyer). This insect has been known to occur in Montana for a number of years, but until the present season it has never been abundant enough to be considered a pest of even the slightest importance. The sudden appearance of millions of looper larvæ in the alfalfa fields was so unexpected and unusual that farmers were thrown into a panic and requests for advice poured into the station from all sections of the state. Many alfalfa growers were especially alarmed because they believed the looper to be the dreaded alfalfa weevil.

Extent of the Outbreak

In Montana the insect attracted attention in all parts of the state but was particularly injurious in the central and south central countries. Definite records of injury were either reported or personally made in the following counties: Sheridan, Dawson, Custer, Rosebud, Big Horn, Cascade, Broadwater, Jefferson, Madison, Gallatin, Missoula, and Sanders.

The outbreak in Montana was so widespread that we were much interested to know how far it extended into other states and a letter of inquiry in regard to the occurrence of the insect in 1914, was therefore, addressed by Professor Cooley, to entomologists in all of the states west of the 96th meridian. By this means it was learned that it had been abundant enough to attract attention and do considerable injury in the following states: South Dakota, Wyoming, Colorado, Oklahoma, Utah, Nevada, California, Idaho and Oregon. Dr. C. Gordon Hewitt wrote that it was also unusually abundant in southern British Columbia and Alberta. Negative replies were received from North Dakota, Nebraska, Kansas, Texas, Arizona, New Mexico and Washington. The courtesy of the several entomologists who so promptly furnished the above data is greatly appreciated and is here acknowledged.

The remainder of this paper is based on observations made by the writer within the state of Montana, with the exception of several references to statements made by entomologists in other states.

Seasonal History

During the first week in May a day-flying Noctuid moth attracted attention in many parts of the state by its unusual abundance. In Bozeman it was particularly abundant about currant blossoms, while in the Clark's Fork Valley, thousands of the moths were attracted to the apple orchards, where they caused some apprehension among fruit-growers. Mr. T. H. Parks writes that in southern Idaho the moths were particularly attracted to cherry blossoms. As a matter of record a number of moths were collected and were determined by Mr. J. A. Hyslop of the Bureau of Entomology as *Autographa gamma californica* Speyer. Because of this insect's former record the incident was considered of but little importance and was for the moment forgotten. The writer happened to be in Billings on June 9 and there learned that some insect was doing great damage to alfalfa on the Huntley Project which is in the Yellowstone Valley about fifteen miles east of Billings. The following day was spent in visiting alfalfa fields on the Project. Everywhere sweet clover and alfalfa were heavily infested with a semi-looper which was recognized as the alfalfa looper.

At this time, June 10, the majority of the worms were in the third

and fourth instars, although some had already pupated and there were many that were still very small. The larvæ were at the height of their abundance on June 15 and continued in diminishing numbers through the first week in July. From pupæ collected in the field on June 10, moths emerged June 25, other moths reared from the first brood of worms emerged as late as July 30.

A second brood of larvæ was expected in late July or early August but so abundant were insect parasites and a bacterial disease that no more larvæ were observed at any time during the remainder of the season. Several adults were taken in the Gallatin Valley during the first week in September.

Plants Attacked and Nature of the Injury

Sweet clover (*Melilotus alba* Lam.) was the favorite in a long list of plants fed upon the larvæ. Sweet clover plants standing in the midst of alfalfa were generally stripped bare of all foliage, while surrounding alfalfa plants were only partially defoliated. Alfalfa was second only to sweet clover and because of its much greater abundance was the plant by far the most generally attacked. When gardens were invaded lettuce was most severely attacked and wild lettuce (*Lactuca pulchella* D. C.), was stripped to the stems wherever the loopers were abundant.

Larvæ were seen feeding upon the following hosts: Sweet clover, alfalfa, red clover, white clover, alsike clover, flax, sugar-beets, corn, lettuce, carrots, onions, peas, beans, cucumbers, muskmelons, watermelons, squash, currants, gooseberries, raspberries, dock (*Rumex crispus* L.), wild lettuce (*Lactuca pulchella* D. C.), lamb's-quarters (*Chenopodium album* L.) and sunflower (*Helianthus* sp.). From Idaho, Mr. Parks reports the larvæ as feeding upon apple foliage.

Grains and grasses were never attacked even where adjoining heavily infested alfalfa fields. Sometimes the larvæ would crawl to such crops for the purpose of spinning their cocoons.

The first crop of alfalfa was nearly ready for cutting when the looper larvæ began to attract attention. In most instances the injury was not noticeable from a distance, but upon close examination it could be seen that a large percentage of the leaf area had been destroyed. Where the infestation was heaviest, fields presented a whitened appearance quite similar to characteristic alfalfa weevil injury. It is hard to state the amount of the injury to alfalfa as very few farmers make a practice of weighing their hay each year. However, on the Bureau of Plant Industry farm at Huntley, where careful records of the weights of all crops are made each year, it was found that the yields from the first cutting were approximately one-half ton less per acre

than for several previous years. A heavy infestation of the alfalfa looper was the only apparent cause for this sudden falling off in weight. The yield was noticeably light wherever the infestation was at all severe. The quality of the hay obtained was also greatly lowered, for the loss in weight was borne by the leaves rather than by the less valuable stems.

Sweet clover was more severely attacked than alfalfa, but as very little is grown for hay, no estimate of the loss in tonnage could be obtained. Many patches growing wild were stripped entirely bare of foliage and in some of them the larvæ were astonishingly abundant. One patch was seen that was literally covered with loopers. On one plant forty-five worms were counted on one small branch and the remaining branches were just as heavily infested, while the ground beneath was covered with a squirming mass of larvæ.

When infested alfalfa was cut, thousands of loopers were left with but a scanty supply of fresh green food and they at once began a migration to other crops. Such a migration was seen at Huntley. An infested crop of alfalfa was cut on June 9 and on the following morning a heavy migration of worms was taking place from the cut alfalfa to an adjacent field of sugar-beets. In less than twenty-four hours from the time the alfalfa was cut, twelve rows of beets at the edge of the field had been eaten clear to the ground and others were much damaged. The owner was attempting to save his beets by spraying with Paris green, but so fast were the worms coming in that the damage was done before the poison could take effect. He was advised to turn water into an irrigating ditch that separated the two fields and by this means the migration was stopped.

Many beet fields were invaded in like manner and their scalloped and irregular margins were very noticeable as one drove along the highways. However, beets that had been defoliated soon sent out new tops and by harvest time could not be distinguished from those that had escaped attack.

Gardens and some of the field crops were attacked in proportion to their nearness to infested alfalfa and sweet clover. A half-acre garden which had been planted to squash, melons, cucumbers, beans, peas, corn, and beets was seen about ten days after it had been invaded by loopers from a neighboring alfalfa field. Not a vestige of the squash, melons, or cucumbers remained; beans and peas existed only as bare stems; corn was badly eaten and beets were sending out new tops after having been eaten to the ground.

Many patches of melons that were attacked made a new growth and set much fruit, but a set-back of several weeks in a growing season which at the best is short, was sufficient to prevent the melons from ripening before the coming of fall frosts.

In several fields observed, flax was stripped of its foliage, but new leaves were very quickly developed and the yield was not materially reduced.

Gooseberries, raspberries, and currants were attacked only where the worms were very abundant and other food was scarce.

Control

The outbreak was so sudden, unexpected and of such short duration that experimental work in control could be carried on only in a very limited manner.

Paris green at the rate of 1½ pounds in 50 gallons of water, and arsenate of lead at the rate of 4 pounds (paste) in 50 gallons of water were effective in killing loopers, but in the case of heavy migrations some method more immediately effective must be employed.

One farmer reported that a dry ditch with the soil at the sides well pulverized was an effective barrier. Another reported killing many worms in his beet field by rolling as it is practiced at thinning time to break the surface crust.

The most successful method of preventing the larvæ from invading crops other than alfalfa was to keep a stream of water flowing through the main irrigating ditches. On the Bureau of Plant Industry farm at Huntley, a count was made of the worms carried past a certain point on an irrigating ditch three feet in width. It ran close to four hundred worms per minute or 576,000 per day. Nearly all of these were drowned and those that escaped were carried into a section where there were no farms. Some of the worms sink immediately when placed in water, while others will float for some time. Once in the water, they seem unable to get out, unless they become lodged against projecting weeds, sticks, etc.

The immediate cutting of infested alfalfa, followed by discing and dragging, as is practiced in Utah for the alfalfa weevil, was recommended, but because of the presence of natural enemies no data as to the effectiveness of these measures were secured.

Natural Enemies

Birds destroyed great quantities of looper larvæ. Brewer's black bird was of great benefit in this respect and could be seen in large flocks feeding upon the caterpillars at haying time.

Insect parasites and disease were deadly in their attacks upon the hordes of worms, killing them off in such numbers that the second brood of larvæ did no damage and in fact was never seen, although a few adults were observed in September. The most effective of these natural enemies were two species of *Apanteles* and a bacterial disease.

Their presence was not noticed until after the worms had reached the height of their abundance, but during the last week in June the white cocoons of the hymenopterons and the blackened and putrid bodies of worms killed by disease were to be seen everywhere in the infested territory.

In the Bureau of Entomology bulletin 95, Part VII, the author, Mr. James A. Hyslop, makes the following statement: "The alfalfa looper has been held in check by a number of parasites and a disease . . . . The time may come, however, when these natural enemies may themselves suffer reverses and temporarily fail to hold the pest in check." Mr. Hyslop's prediction has certainly come true and the wisdom of collecting and publishing biological data concerning insects that are not of immediate economic importance is again emphasized.

THE CITRICOLA SCALE

(*Coccus citricola*, Camp.)

By H. J. Quayle, *Citrus Experiment Station, Riverside, California*

Six or seven years ago some of the horticultural officers of southern California, particularly Mr. Cundiff and Mr. Pease, horticultural commissioners of Riverside and San Bernardino Counties, had observed cases where fumigation was not effective against what was supposed to be the soft brown scale (*Coccus hesperidum*). In these cases, too, the scale was generally distributed over the old trees in the grove, while usually the soft brown scale occurs more commonly on young trees or a few twigs or branches of older trees. Some specimens of what was supposed to be this new variety of scale were at the time sent to the Bureau of Entomology as well as to the writer. The scales were identified in both cases as *C. hesperidum*. But further general observations showed that the scale in question was very sparingly attacked by parasites, and that ants were not attracted to it in large numbers, both points being the reverse of what is true for *C. hesperidum*. At about the same time this variety was discovered at Claremont, and it was identified by Mr. Essig as *Coccus longulus* and later as *C. elongatus*. When an incidental study of this scale was started by the writer in 1911, it did not appear to agree positively with any of the species that it had previously been placed under. In 1913 Mr. Roy E. Campbell was engaged as an assistant to work particularly on this scale, and as a result of these studies, it was determined as a new species and was given the name of *Coccus citricola*.[1]

This scale is now known to occur over widely separated localities in California and attacks citrus trees primarily. It has been found also

[1] A New Coccid Infesting Citrus Trees in California. By Roy E. Campbell, *Entomological News*, Vol. XXV, May, 1914.

on pomegranate, nightshade, elm, and English walnut where these occur near infested citrus. Its origin is at present unaccounted for, but further studies may place it under some foreign form already described. The fact that it is a pest at present of citrus entirely and has not been taken on any native plant seems to indicate that it has been introduced.

The citricola scale has spread very rapidly in some sections. While it was practically unknown in Tulare County two years ago, it now occurs in most of the citrus sections of that county. It occurs in such abundance in some groves there that, on account of the weakening effect on the tree, fruit production has fallen off as much as 50 to 75 per cent. Fumigation and scale control was unknown in that county until the present year, but during this season a very general inauguration of such measures has been made. Excepting in a few localities, the infestations in southern California are not so severe as in the San Joaquin sections. The further fact that this scale is susceptible to fumigation for so short a period makes it an important economic factor in the citrus industry of California.

Aside from the general economic differences between this species and *C. hesperidum*, the life-history and habits differ in the two species. *C. citricola* always deposits eggs which may hatch immediately or after a day or two. In *C. hesperidum* the young are brought forth alive. There are several generations a year of *C. hesperidum*, while there is but one or a partial second in the case of *citricola*. Many of *hesperidum* may mature on the leaves, while *citricola* invariably migrates back to the twigs.

The young of *C. citricola* began to appear in 1914 about April 20 and continued until August. They settle on the leaves almost entirely, and mostly on the under side. In November and later they migrate back to the twigs. During the summer, fall and winter, they grow but little but rapidly mature in the early spring. The first molt occurs approximately one month from birth and the second molt a month later.

The following identified species of parasites have been reared from this scale: *Coccophagus lunulatus* How., *C. lecanii*, *C. flavoscutellum* How., *Aphycus* near *flavus*. One or two others are not yet identified.

A peculiarity in the control of this species is that it becomes very resistant to fumigation after early in September. No evident changes in the scale itself have been noted at this period. The black scale and others at the same size would be very readily killed by fumigation. Spraying has not proved to be very satisfactory, as is the case of all spraying for scale insects on citrus trees. Fumigation, between July 15 and September 15, has proved satisfactory, and is the treatment recommended.

OBSERVATIONS ON THE OVIPOSITION OF CERTAIN CAPSIDS[1]

By HARRY H. KNIGHT

The scarcity of knowledge in regard to oviposition by members of the family Capsidæ led the writer to undertake observations on those species of greatest economic importance in Genesee County, N. Y. During the past summer the following species were observed and their method of oviposition studied in detail: The Apple Red Bug (*Heterocordylus malinus* Reut.); False Apple Red Bug (*Lygidea mendax* Reut.); False Tarnished Plant-bug (*Lygus invitus* Say); and *Paracalocoris colon* Say.

While working in the field in coöperation with the Genesee County Fruit Growers' Association, the writer has had an unusual opportunity to observe these capsids over a large extent of territory. During the present year (1914) the Apple Red Bugs have proved to be among the most injurious insects attacking the apple in western New York. The rapid development of both species as pests has been quite remarkable. Described as new species in 1909 and life histories studied for purposes of control the same and following years (1911), such has been the brief history of these pests. It has been supposed that the apple red bugs were native to the hawthorn and wild crab and from these came over to the cultivated orchards. This theory is well supported by recent observations made in the field. On June 18, 1913, seven nymphs and some adults of *Lygidea mendax* were collected on *Cratægus* sp. in an old pasture near an apple orchard where the species was likewise abundant. Nymphs of both species were found abundant on hawthorn, wild crab, and wild apple trees May 24, 1914, at Portage Falls, in the valley of the Genesee River. Characteristic injury caused by feeding on the tender leaves and shoots was noted on all of these plants. This locality forms a natural and isolated breeding place for both species with no cultivated orchards within a radius of two miles.

THE APPLE RED BUG (*Heterocordylus malinus* Reut.)

The eggs of both species (*H. malinus* and *L. mendax*) and places where they are found have been described by Prof. C. R. Crosby (1911) in an excellent bulletin on these insects. No observations are recorded giving the time and manner of the deposition of the eggs. The first adult of the apple red bug (*H. malinus*) was taken June 7 but the majority of the species matured about June 12. Daily observations were made on the adults confined in cages and under natural

[1] Contribution from the Department of Entomology of Cornell University.

conditions on the trees. By June 19 many females were noted to be heavy with eggs but none were observed to oviposit until June 21. For purposes of photography the females were caged on suitable apple branches under large glass cylinders. The best results were obtained by keeping but one female in a cage. On the morning of June 23, four different females were observed while ovipositing. When a female is ready to oviposit she moves up and down the branch patting the surface with her antennæ and touching the wood here and there with the tip of the proboscis. In this manner one spent six minutes searching for a place to oviposit. Another individual required fifteen minutes before a suitable place was found. The female begins to drill the hole by means of the proboscis (Fig. 1, pl. 11). This operation may require from five to eighteen minutes before the hole is ready for the insertion of the ovipositor. After drilling the hole with the beak, the female arches the abdomen, stands as high as possible, then unsheaths the ovipositor and thrusts it forward to locate the place prepared (Fig. 2, pl. 11). The head is turned under with the tip of the proboscis in the hole to help guide the ovipositor. Even with this assistance the insect is not always successful. One female was observed to make seven attempts before inserting the ovipositor. Most individuals make two or three attempts before succeeding. After each failure, the hole is inspected and worked upon for a time with the beak. Once the ovipositor is started, the abdomen is worked up and down with a rapid jerky motion until the ovipositor is inserted nearly to its base (Fig. 3, pl. 11). An alternate contraction and expansion of the abdomen then occurs while the egg is being worked down into position. This operation requires about two or three minutes. The ovipositor is then withdrawn and a rest of three to five minutes follows before inserting the second egg. After this interval, the hole is again located by means of the antennæ and beak and then the operation of inserting the ovipositor is repeated. In some cases only one egg was laid in a place but two eggs appear to be the normal number. In one instance a female laid two eggs in each of three holes which were close together. All these eggs were placed in a line forming a ring at the junction where new growth started in the spring from a terminal twig (Fig. 6, pl. 11). Another favorite place is at the base of a new fruit spur. Figure 5, pl. 11, shows how such a spur was broken out and two eggs left exposed. The eggs are slightly curved and follow the cambium layer without penetrating the solid wood.

On June 21 seven females of *H. malinus*, apparently in an egg-laying condition, were captured on hawthorn at Portage Falls, N. Y. These were brought to the insectary and placed in cages on suitable apple branches. Two of these females were observed to oviposit on June

23. On the morning of June 24, one individual was photographed while ovipositing on apple. This female was then placed on a branch of *Cratægus* sp. and other photographs were obtained the same afternoon (Fig. 1, pl. 11). Thus it is seen how easily the species may go from hawthorn or wild crab to the cultivated apple.

The number of eggs laid varies with the individual from day to day. One female was observed to oviposit in six different places between 10.00 a. m. and 12.00 o'clock noon. This same female was observed to oviposit daily from June 23 to June 27, but died on the 28th. One female captured June 21 and kept in a cage was observed to oviposit as late as July 5 but was found dead on the 7th. Several females were captured July 5 on Cratægus and wild apple trees near Attica, N. Y. The wild fruit showed characteristic red bug injury as seen in cultivated orchards (Fig. 11, pl. 12). Two females heavy with eggs were captured on quince, July 11, at Byron, N. Y. Characteristic injury was observed on the quince fruit. Four females were taken on *Cratægus* sp., July 13, near Batavia. One of these individuals lived in the insectary until July 17. No more specimens were taken after this date.

False Apple Red Bug (*Lygidea mendax* Reut.)

Lygidea mendax matures from seven to ten days later than *H. malinus*. The first adult was captured on June 14 but the majority of the species matured about June 20. Several females were watched closely but no eggs were obtained until July 8. The adults may be seen to feed on the branches with proboscis deeply inserted for several minutes at a time. These holes are never used for inserting eggs. When ready to lay, the female moves about over the twigs searching for lenticels on wood of the previous year's growth. Several of these may be tested with the tip of the beak before one is selected for ovipositing. The behavior of this species is very similar to that of *H. malinus*. The lenticel is drilled out by means of the proboscis. One female required ten minutes for this operation. Three attempts to insert the ovipositor failed but on the fourth she succeeded (Fig, 4, pl. 11). It took two and one-half minutes to lay the egg. After an interval of four minutes, she returned to the hole and upon the second trial inserted the ovipositor and laid an egg. After this the wound was sealed by means of the proboscis. The lenticels are normally light colored but after being injured by the process of oviposition, they appear reddish brown. By this means one soon learns to locate those containing eggs. The normal number of eggs laid in a lenticel is two but in seven cases only one egg was found (Fig. 7, pl. 11). The eggs are placed in the cambium at such an angle that the lower ends may rest on solid wood and their tips be 1.5 mm. apart.

In order to get pictures of the bugs laying eggs, it was found that time could be saved by caging them for two days on leaves only, and then placing them on suitable branches before the camera. They are usually ready and anxious to deposit eggs by that time.

Females were observed ovipositing on the trees as late as July 18. Specimens were still on the trees July 22, but most of them disappeared with the cold rains that followed. A search was made on July 27 but no specimens were obtained on trees where they had formerly been abundant. This species was found numerous on hawthorn and wild crab along with *H. malinus* at Portage Falls, N. Y. The species has also been found breeding on quince trees.

The False Tarnished Plant-Bug (*Lygus invitus* Say)

This Capsid causes serious injury to pears, and is well described in a bulletin by Parrott and Hodgkiss (1913). The nymphs of this species have been found abundant on pear branches where they injure the fruits, but no records exist giving the time when eggs are laid or where they are placed.

This species is perhaps the most difficult in which to observe oviposition of eggs. Several females were kept in cages on pear branches but only one individual was observed to oviposit. This observation was made on the morning of June 26. Other females which were heavy with eggs were observed daily to feed on pear fruit and on the branches but no effort was made to oviposit. The female observed to oviposit was first discovered when the ovipositor was inserted nearly to its base in a fresh pear shoot of the present year's growth. After two minutes, the ovipositor was withdrawn. The female turned, inspected the hole, then moved along the branch about two inches. After five minutes, she became very active and proceeded along the branch feeling with antennæ and beak. She soon returned to the spot where eggs had been placed before, and with proboscis to mark the opening, she raised up, unsheathed the ovipositor and made the insertion much in the same manner as observed in the case of apple red bugs. A period of two minutes elapsed before the ovipositor was withdrawn. Upon examining the branch, it was found that six eggs had been laid in a space 1 mm. long. The eggs were closely packed in a double row lying flat just within the cambium layer (Fig. 8, pl. 12). Three of the eggs were injured in opening the cavity, thus they do not show well in the photograph. Of two eggs measured, the length is 1.05 mm. by .26 mm. wide.

The nymphs and adults of *L. invitus* were found most abundant on a row of Bartlett pears very close to a hedge-row of young elms and black locust. On June 5, the nymphs were found on both the pear and elm branches. Adults were reared from nymphs captured on the

elm shoots. On June 25, adults were quite numerous on both elm and pear trees. A search was made on the elm branches to see if eggs were being deposited there. One capsid egg was found inserted in the tender bark, which in size and appearance corresponded to that of *L. invitus*.

On June 20, two females and one male were placed on pear branches within a cheesecloth cage. The male died about the middle of July, while the two females were alive on August 6, but dead on August 8. No eggs were found in the branches. These adults produced characteristic injury to a pear growing within the cage.

An Apple Capsid (*Paracalocoris colon* Say)

This is a species which was found rather commonly on apple trees during the past summer. The brownish-red and white banded nymphs may be found feeding on the tender shoots and foliage in a manner similar to apple red bugs. However, the fruits which are punctured do not develop such deformities and scars as result from feeding by red bugs. The first adult was taken June 15. Oviposition was first observed on July 3. This species oviposits in places quite different from any capsid heretofore observed. The females prefer to oviposit along the margin of dead wood, such as stubs caused by the breaking off of limbs. Females which were caged on limbs free from scars did not oviposit. Three individuals were induced to lay by placing them on branches which had broken stubs (Fig. 10, pl. 12). One female was observed to oviposit on the tree. In this case, the egg was placed in the margin of a wound caused by the splitting off of a small branch. The female prepared a place in the margin of the live bark by means of the proboscis. The ovipositor is then thrust forward and worked into place with a rapid jerky motion. It requires from three to four minutes to insert the ovipositor and lay an egg. Five eggs were placed around the margin of one stub, a new hole being made for each egg (Fig. 9, pl. 12).

The egg is 1.2 mm. long by .2 mm. in width. It differs from other Capsid eggs by having a white cap with two keels that curve up and nearly meet over the top of the egg (Fig. 13). The cap projects from the cavity as shown in the figure, but is not conspicuous due to the uneven character of the rough bark and surrounding wood. Most of the eggs were deposited during the first two weeks in July. The last specimen captured was a female taken on July 28.

Fig. 13. Egg of *Paracalocoris colon* showing the cap with keels.

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PLATE 11

Fig. 1. *Heterocordylus malinus* drilling with proboscis, preparing to oviposit in Cratægus.
Fig. 2. *H. malinus* inserting the ovipositor.
Fig. 3. *H. malinus* with ovipositor inserted nearly to the base.
Fig. 4. *Lygidea mendax* with ovipositor inserted in lenticel.
Fig. 5. Two eggs of *H. malinus* laid at the base of a new fruit spur.
Fig. 6. Showing holes made by *H. malinus* in ovipositing at the junction of new growth and the old twig (enlarged).
Fig. 7. Bark removed to show egg of *L. mendax* (enlarged).

PLATE 12

Fig. 8. Eggs of *Lygus invitus* as deposited in pear branch (x2).
Fig. 9. Bark removed to show egg of *Paracalocoris colon* laid at base of dead stub.
Fig. 10. *P. colon* at the point of ovipositing.
Fig. 11. Natural fruit showing red bug injury.
Fig. 12. Cratægus leaves showing typical red bug injury.

COTTON SEED OIL SOAP AS A SUBSTITUTE FOR WHALE OIL SOAP[1]

By W. W. YOTHERS, *Bureau of Entomology, Orlando, Florida*

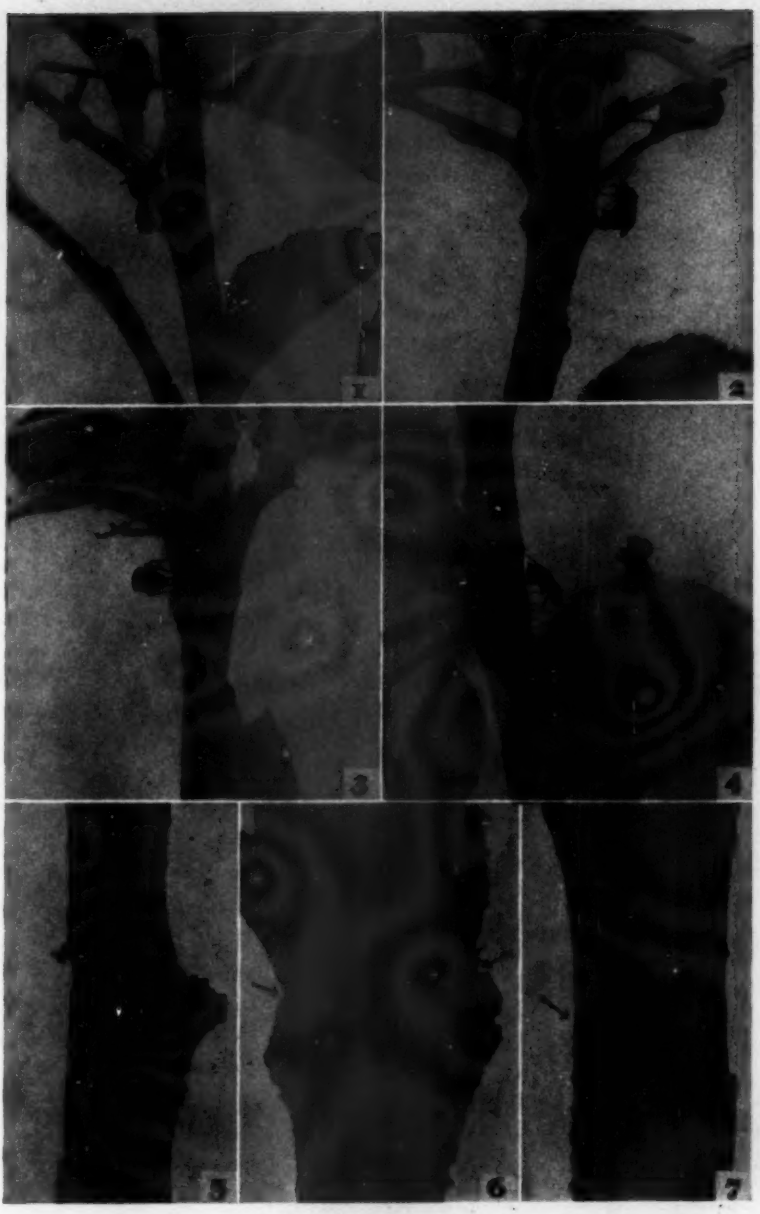
Many people, including some entomologists, find the odor of fish oil soap very disagreeable. Especially is this the case if it is used on plants in a conservatory or greenhouse. With a view to finding a substitute for whale oil soap much experimenting was done with cotton seed oil and the following formula was originated:

2 quarts of cotton seed oil,
6 ounces of caustic potash,
1 quart of water.

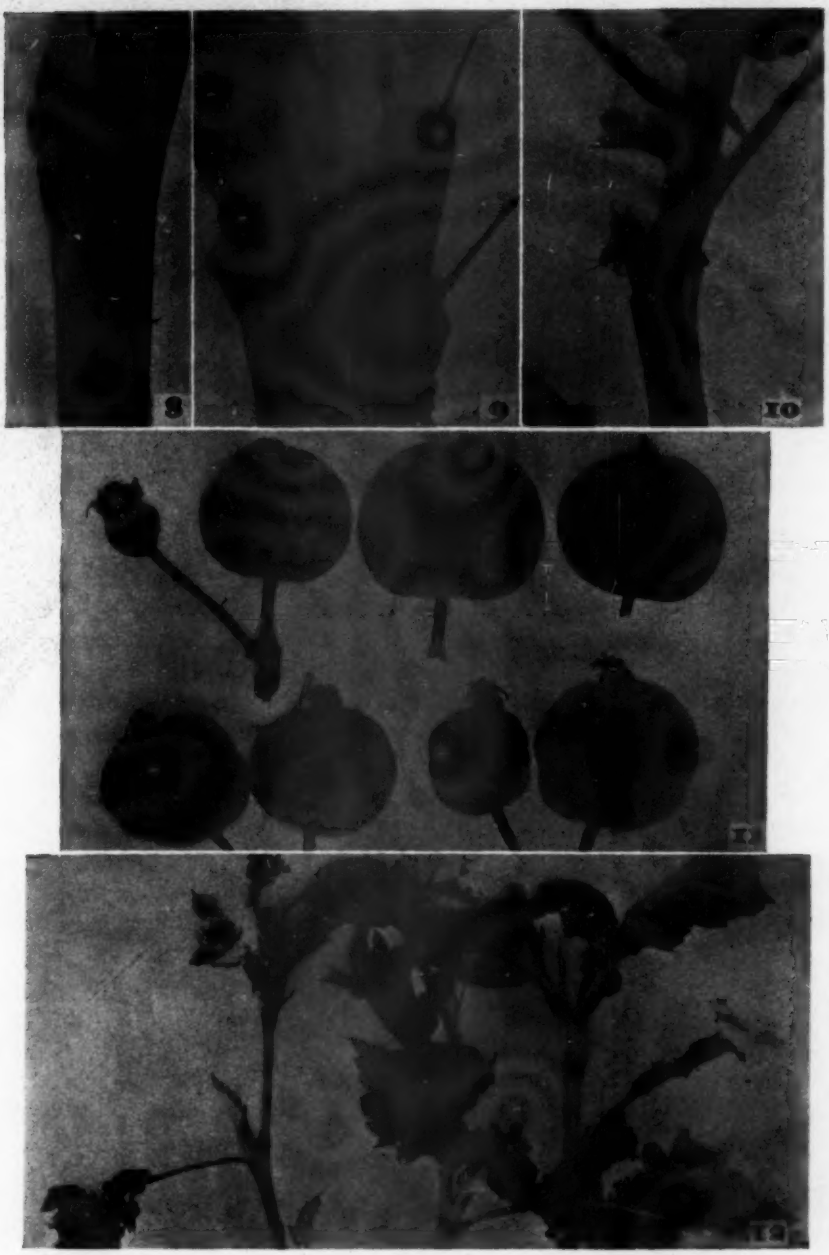
Directions: Dissolve the caustic potash in the water and heat until it boils vigorously. The oil then should be added very slowly. It should be added in such a way that the boiling should not cease. A few minutes after all the oil has been added the soap is finished. Stirring, of course, must be continued throughout the process.

This formula contains $63^{7}/_{10}$ per cent of oil, $31^{8}/_{10}$ per cent of water and somewhat less than 6 per cent of caustic. The product has about the same consistency as ordinary fish oil soap and is quite easily handled.

[1]Published by permission of the Chief of the Bureau.



Capsid oviposition



Capsid oviposition

About two years after this work was done it was found that this is about the regular formula for the manufacture of soft soap from cotton seed oil, as given in various publications. This formula can also be changed so that it will contain from 43 to 50 per cent of oil and the product resulting will be quite satisfactory.

The experiments so far indicate that this soap can be used as a substitute for fish oil soap and we would recommend that entomologists try this for greenhouse plants and other plants where the people object to the odor of fish oil soap.

REARING OF MOTHS AND TACHINA-FLIES FROM LARVÆ AND PUPÆ OF ARMY-WORM IN NORTH CAROLINA IN 1914

By FRANKLIN SHERMAN, JR., *Entomologist, State Department of Agriculture, Raleigh, N. C.*

In Vol. 1, p. 354 of this JOURNAL, Prof. Z. P. Metcalf gives data on parasitism of army-worm (*Heliophila unipuncta* Haw.) by the Tachina-fly (*Winthemia 4-pustulata* Fabr.). His data was secured from worms collected during an outbreak at Durham, N. C., in August, 1908.

On July 29, 1914, the writer, with Mr. C. L. Metcalf, collected many army-worms (*H. unipuncta*) near Neuse, N. C., thirteen miles north of Raleigh. These were sorted into lots according to the number of parasitic eggs we could detect on each worm, and rearings were made (1) by placing numbers of similarly parasitized worms in the same cages and (2) by placing individual worms in separate vial-cages.

All cages had one to three inches of moist sifted earth, and plenty of fresh grass supplied so long as needed. Examinations were made almost daily while developments were taking place. From the way in which healthy worms fed and grew I believe that few died from the handling or artificial conditions, though the mortality was high even among those not apparently infested with insect parasites.

From 534 army-worms, showing 1,313 parasitic eggs, we reared a total of 18 adult moths and 296 parasitic flies, these representing 220 *Winthemia 4-pustulata* Fabr. (which was the only one reared by Prof. Metcalf in 1908), *47 Phorocera claripennis* Macq., and *4 Goniomyia unifasciata* Desv., while 25 flies were mutilated, deformed and not identifiable (these were in all probability of the first two species named in this paragraph).[1]

It was found that the larvæ of *W. 4-pustulata* left the dead larval host and went deeper into the soil (½ to 1½ inches) to form their puparia. In no case where this fly issued did the host form the pupa, though the

[1] Not taking into account a number of Sarcophagid flies which emerged in the larger cages.

occasional formation of the pupal cell was noted, and in every case the fly-puparia were found free in the earth. The same held true for *P. claripennis* so far as noted.

In cases where *G. unifasciata* was reared the host pupated and the fly-parasite emerged from the pupal host.

We have preserved in our collections one army-worm with 16 evident parasitic eggs—one with 17 eggs, and one with 34 eggs, these being the highest numbers found.

The rearings from the army-worms collected at Neuse, N. C., and which showed from 0 to 15 parasitic eggs per worm, are indicated in the following table.

REARINGS FROM ARMY-WORMS FROM NEUSE, N. C., 1914

Visible Parasitic Eggs per Worm	Worms	Moths Reared	Tachina-flies						Flies	Fly Eggs	Per cent Flies to Fly Eggs
			Winthemia 4-pustulata Fabr.		Phorocera claripennis Macq.		Goniomyia unifasciata Desv.				
			♂	♀	♂	♀	♂	♀			
0	158	15	0	0	1	0	1	3	5		
1	96	1	7	11	0	2	0	0	20	96	20.83
2	76	0	19	17	1	4	0	0	41	152	26.97
3	64	0	21	26	5	11	0	0	63	192	32.81
4	36	1	12	22	3	3	0	0	40	144	27.77
5	30	1	18	15	1	1	0	0	35	150	23.33
6	24	0	8	12	1	1	0	0	22	144	15.27
7	18	0	5	6	2	4	0	0	17	126	13.49
8	14	0	3	5	1	1	0	0	10	112	8.92
9	5	0	1	2	0	0	0	0	3	45	6.66
10	5	0	0	2	1	0	0	0	3	50	6.00
11	1	0	2	1	0	0	0	0	3	11	27.27
12	3	0	0	1	0	2	0	0	3	36	8.33
13	2	0	0	4	0	0	0	0	4	26	15.38
14	1	0	0	0	1	0	0	0	1	14	7.14
15	1	0	0	0	1	0	0	0	1	15	6.66
Totals	534	18	96	124	18	29	1	3	271 +25*	1,313	
			220		47		4		296		

* 25 flies were deformed, mutilated, lost, or otherwise not identifiable.

It will be noted that from 158 worms, which bore no visible eggs, we reared 15 adult moths (less than 10 per cent) and that 5 flies, all but one of which were *G. unifasciata*, emerged. One moth issued from the worms showing one egg each, one moth from worms with 4 eggs each, and one moth from worms showing 5 eggs each. No moths were reared from 74 worms showing from 6 to 15 eggs each.

While admitting that the numbers involved are not large enough to furnish an absolute criterion, yet the per cent of fly-eggs which produced flies give some interesting suggestions. The mortality among the flies (from egg to adult) was less among those where there were 2 eggs per worm, than among those which had one egg per worm,—and the mortality was still less when there were 3 eggs per worm. This suggests that where there are only one or two eggs per worm, the worm may have sufficient vitality to prevent the development of the parasitic larva inside the host. The highest percentage of flies was secured where there were 3 eggs per worm, and from this we may argue that when the worm bears 3 eggs there are enough parasitic larvæ to more certainly kill the host before the larvæ perish inside and the parasitic larvæ can still find sufficient nourishment to mature. The per cent of flies maturing declines consistently when we pass above 3 eggs per worm until we reach 11 eggs per worm, but beyond this point the numbers involved in the rearings are certainly too small to warrant conclusions. Indeed, I feel that all above 8 eggs per worm are supported by too little data to warrant any real dependence being placed on them.

We often reared 2 adult flies from one worm, in several cases, 3 flies from one worm, and in one case we reared 4 adult flies (*W. 4-pustulata*, 1 ♂ 3 ♀) from one worm which showed 4 eggs when caged.

One worm showed 3 eggs July 29; on August 3d it was still active though two parasitic larvæ had certainly entered, yet the worm partially pupated and then perished, neither moths nor flies developing. In no case did we secure both a parasitic fly and an adult moth from the same worm, nor did Professor Metcalf note any such occurrence in 1908.

Rearings from Army-Worm Pupæ

While looking into an army-worm outbreak in Haywood County in the mountains of western North Carolina, I secured a lot of pupæ (not counted). From these we could not expect to rear *W. 4-pustulata*, or *P. claripennis* which leave the dead larval host. But we included a few separated fly-puparia which were found among the pupæ in the field. All were put in one cage. Result:

Army-worm Moths	23	
Tachina-flies	*Architas analis*, Fabr. 13	(6 ♂, 7 ♀)
	Goniomyia unifasciata, Desv. 10	(5 ♂, 5 ♀)
	Winthemia 4-pustulata, Fabr. 1 ♂	
	Phorocera claripennis, Macq. 1 ♀	

From the abundance of pupæ in the field in Haywood County it was evident that *W. 4-pustulata* and *P. claripennis* had not been so active in subduing the worms as they had been at Neuse, where we found

very few pupæ after the larvæ disappeared. Yet the fact that we reared a specimen of each from the stray puparia collected shows that both species had been present. These army-worm pupæ yielded as many flies as moths, approximately equally divided between *A. analis* and *G. unifasciata*.

These rearings and observations taken together with those of Professor Metcalf in 1908 indicate that *W. 4-pustulata* is the chief insect parasite of the army-worm in the central part of North Carolina, and that *P. claripennis* was also an appreciable factor in 1914. *A. analis* and *G. unifasciata* both killed many pupæ in western North Carolina in 1914.

Braconid and Ichneumon parasites (Hymenoptera) were noted or reared on only an insignificant percentage of the army-worms. Several predaceous enemies were noted in the field but in no case enough to be an important factor. We believe that bacterial diseases played a part, but secured no confirmation on this. The largest natural factor noted was the Tachina-fly family.

The indentifications aré by Mr. H. E. Smith of the Bureau of Entomology, Washington, D. C., to whom I desire to express thanks.

RELATIVE SIZE IN FUMIGATION

By C. W. Woodworth

The measurements now always taken in obtaining the size of fumigation tents are the distance over the top and the circumference. Most tables now in use are incorrectly calculated because equal values have been given to both dimensions.

It will be evident at once that the distance over is changed with a change either in the height or the diameter of the tree and that therefore it is the more important of the two.

The possibility of adding to this dimension an amount dependent on the difference between the two measurements which will indicate the proportionate size of a tent gives us a new and very convenient and accurate method of rating a tree for dosage.

This we will call the "relative size" of the tent. If the proportions of a tent remained constant the distance over could then be taken as the relative size. Since the distance around always equals or exceeds the distance over we may select as standard a tent with these two measurements equal. The amount to be added to this to allow for wider and shorter tents is one fifth of the difference between the two measurements. Thus a tent 20 x 30 would have a relative size of 22 and should

have a dose equal to that of a tent 22 x 22. It will not be necessary to explain here why one fifth is the correct factor.[1]

The adoption of this plan of relative sizes makes it possible to present a table of dosage in an exceedingly simple form, and to make the adjustments for different degrees of leakage also very easy.

DOSAGE TABLE

Ounces of Sodium Cyanid

Relative							Leakage x		x		.35%	x		x		x	%
Size	64	61	58	56	53	50	47	44	42	40	37	35	32	30	28	26	24	22	20	18	16	15	13	11	10	ft.
40	36	32	28	24	20	18	16	14	12	10	9	8	7	6	5	4½	4	3½	3	2½	2	1½	1½	1½	1	½	¼	¼

Relative size equals distance over the tent plus one for each 5 ft. of difference between the measurements.

Leakage more than .25% is read to the left and if less to the right, one number for each .05% more or less than .25%. Do not fumigate trees smaller than number of feet equal to .00% of leakage. *Holes* produce leakage requiring the use of the next number to the left when equivalent to a triangular tear half as many inches long as relative size and quarter as wide as long.

Stronger dosage for purple scale may be read one or two numbers to the left and

Weaker dosage for black scale one or two numbers to the right.

Acid corresponding with any dose is given 2 numbers to the left and

Water 3 numbers to the left of the acid dose.

In the foregoing table the approximate size of the minimum dose is indicated by asterisks except for .25 per cent which is printed to emphasize that this table is for that degree of leakage.

The first line of figures gives the relative sizes corresponding with the doses on the following line. The intervals range from 1-3 and the dose intervals from ¼ oz. to 4 oz. This corresponds quite closely with previous tables and with actual practice.

The table in fact will be soon memorized. It will be noticed that the intervals of the upper line just above 10 and 15 are 1 and that other intervals are two except just below 35 and 40 and above 44. The doses corresponding to 10, 20, 30, and 40, are ¾, 2½, 5, 9, and with 64 is 32 oz. The intervals in the dose line are by quarter ounces to 2, half ounces to 5, ounces to 10, two ounces to 20 and four ounces to 40.

The acid and water dose is usually calculated mentally; if to be read from the table cut a card as wide as five numbers. Held against the table the two corners will indicate cyanid and water and a line on the card may be drawn to point to the acid dose. Or prepare a card by cutting out a hole or notch wide enough to enclose five numbers and have this line to indicate acid as before.

The mental effort in calculating the relative size will not be found to

[1] Bulletin 220, Cal. Agr. Exp. Sta., p. 5.

be difficult and is decidedly easier than the process of adding the two figures which is now done in obtaining the distance over.

A few examples will help in understanding the process. A tent 20 x 30 gives a relative size of 22 (difference 10 giving 2 to add to the 20) and the dose given on the table under 22 is 3 oz. 25 x 37 gives a dose a little over 27 and the dose of 28 which is 4½ oz. would be correct.

Where the leakage is not .25 per cent or other factors enter into the calculation, the process is still very simple and easy. Thus with a .30 per cent, 23 x 28 tree, the dose would be 4 oz. instead of the 3½ shown in the table based on a .25 per cent leakage.

Taking about the most complicated case—a 20x26, 15 per cent tent, with rents amounting to 10 sq. in., determine the weakest dose for black scale. The size would indicate 3 oz. and the dose would have dropped to 2 oz. because of the tight tent, but for the holes which moves the number to 2½ and finally the weak dose for black scale drops it down two intervals to 1¾ which is correct under these conditions.

If one had in this case a .30 per cent leakage the tent should not be used because the relative size is less than 30 and efficient fumigation is not to be expected.

There can be no doubt that all these factors should be taken into consideration in fumigation if the best work is to be done and this dosage table may help to remove the difficulties which have hitherto seemed to the fumigators to be insurmountable.

THE USE OF WATER UNDER PRESSURE FOR THE CONTROL OF MEALY BUG[1]

By W. W. Yothers, *Bureau of Entomology, Orlando, Florida*

Owing to the ineffectiveness of spraying with insecticides for the control of mealy bugs in Florida it is interesting to know how a citrus grower controlled this pest successfully. These results were obtained by Mr. A. H. Brown, manager of the Atwood Grapefruit Company, Manavista, Florida.

This grove of more than 200 acres is fitted with a high pressure irrigation system throughout and hydrants are placed at intervals so that hose 100 feet long when attached will reach all the trees. The system furnishes about 60 pounds pressure. When used to control the mealy bugs a nozzle made out of three-fourth inch pipe three feet long is used. The end is flattened so that the aperture is about 1 inch wide and one-eighth of an inch opening. Since the mealy bug con-

[1] Published by permission of the Chief of the Bureau.

gregates largely where the fruits touch, the stream is directed at these places and the mealy bugs are knocked off on the ground. About three applications of this irrigation system is sufficient to control quite a severe infestation. This involves little extra expense since the water is usually needed in a grove.

In view of the extraordinary success of this instance, it is certainly advisable to experiment with water sprayed under pressure from the ordinary spraying machine. In view of the fact that as yet no insecticide will kill the mealy bug to any extent and no other system of spraying is a matter of record, to my knowledge, I think Mr. Brown deserves much credit.

ENTOMOLOGICAL MUSEUM OF THE UNIVERSITY OF KANSAS

The following is a tabulation of the number of species and specimens:

	Number of species varieties in regular named collections.	Number of specimens in regular named collections.
North American Coleoptera	8,089	35,052
" " Lepidoptera	3,756	12,208
" " Diptera	2,244	6,741
" " Hymenoptera	1,304	3,912
" " Hemiptera	1,064	3,724
" " Orthoptera	492	1,845
" " Neuroptera	293	
Exotic Coloptera	2,600	8,450
" Lepidoptera	981	1,716
Collections for studies in geographic distribution, variations and economic problems		190,000
Grand totals	20,803	263,640
Grand totals in Museum		284,451

Summary of Types in Snow Entomological Collections

Neuroptera	1
Orthoptera	15
Hemiptera	45
Coloptera	12
Diptera	490
Lepidoptera	100
Hymenoptera	259
African Diptera	25
Total	947

Scientific Notes

The Box Leaf Miner. There appeared in Newport in the spring of 1912 an insect which threatened to be disastrous to the shrub known as boxwood. My attention was first called to it when it was in the larval form in May. I recognized this insect at once as a miner and endeavored to find out its life history, but being unable to do so I have studied it with the following results:

Beginning in May when the insect first seemed to gain life in the leaf, I watched it grow until the first of June when it appeared to eat its way through the leaf and little flies dropped to the ground, where, after struggling for a few moments suddenly became possessed of wings and flying around at a distance of but a few feet from the plant, soon mated and as near as I could tell seemed to lay their eggs in the upper epidermis of the leaf. This went on for about six days when the flies suddenly disappeared and I found large numbers of them on the ground apparently dead, and I came to the conclusion that the male, after copulating, had died and the females after laying their eggs had followed the same course. This was all that I saw of the insect until about the 15th of August when little wart-like protuberances appeared on the leaves and upon examination I found very small larvæ again working there. I paid very close attention, as I thought perhaps within a few weeks there would be a new brood hatched, but I was somewhat dismayed when, after waiting for a couple of months, I found that there was no new brood of flies but that the larvæ had gone into winter quarters.

Being thus assured of the life history of the insect I endeavored to attack it by means of fumigation in the early spring, but failing in this I waited for the flies to appear in June when I prepared as many as a dozen different contact sprays to kill the insect when it appeared in its adult form. We sprayed the flies every other day, making a total of three sprayings, and of all the sprays which I used there was none which gave the immediate satisfaction as did that of soluble sulphur in the powdered form, which I used at the rate of four pounds to fifty gallons of water. This was the most effective spray which did not injure the plants and has worked successfully on all estates where used.

H. C. Walker.

Conference of Officials engaged in Gipsy Moth Work. On February 13, 1915, a conference of officials engaged in gipsy moth work was held at the Boston office of the Bureau of Entomology for the purpose of discussing gipsy moth conditions in order to secure as much uniformity of work and general coöperation as possible among those engaged in this project.

Dr. L. O. Howard, chief of the Bureau of Entomology, presided at the meeting and the following officials and visitors were present:

Dr. C. Gordon Hewitt, Dominion Entomologist, Ottawa, Canada.
Mr. L. S. McLaine, Assistant in Gipsy and Brown-tail Moth Work, Ottawa, Canada.
Hon. W. T. Guptill, Commissioner of Agriculture, Augusta, Me.
Mr. E. J. Cady, Special Agent in Charge of Gipsy Moth Work, Portland, Me.
Hon. A. L. Felker, Commissioner of Agriculture, Concord, N. H.
Prof. W. C. O'Kane, Deputy Commissioner, in Charge of Moth Work, Durham, N. H.
Mr. Harold L. Bailey, in Charge of Suppression of Insect Pests, Bradford, Vt.
Dr. H. T. Fernald, State Inspector of Nurseries, Amherst, Mass.

Prof. A. E. Stene, State Entomologist, Kingston, R. I.
Mr. C. W. Loveland, Assistant Entomologist, Providence, R. I.
Dr. W. E. Britton, State Entomologist, New Haven, Conn.
Mr. I. W. Davis, Assistant Entomologist, New Haven, Conn.
Dr. T. J. Headlee, State Entomologist, New Brunswick, N. J.
Mr. Philip B. Ayers, Secretary of Society for the Protection of New Hampshire Forests, Boston, Mass.
Mr. E. L. Reynolds, Secretary of Massachusetts Forestry Association, Boston, Mass.
Mr. C. B. Williams, Mr. Ernest Hargreaves, and Mr. George H. Corbett, Carnegie Scholars, who are studying problems in Economic Entomology in this country; and a number of representatives of the Bureau of Entomology engaged in all different lines of investigation and field work which are being carried on in connection with the gipsy moth project.

Other officials having charge of moth work in Massachusetts, New York, and Ohio, were not able to be present at the meeting.

The meeting was called to order by Dr. Howard and a statement was given by representatives from each state and the Dominion of Canada concerning the existing conditions and the methods which were being used to control both the gipsy and brown-tail moths.

This was followed by a brief statement by Dr. Howard, in which he indicated that Federal work on these two insects had been brought about largely because of the fact that the states infested were attempting to control these insects. He further stated that there seemed to be little disposition on the part of Congress to discontinue appropriations so long as it could be shown that the states were doing their part in stamping out these pests.

Statements were then made by members of the Federal gipsy moth force in regard to the different lines of work which were being carried on and the results which have been accomplished.

The parasite and other experimental work was briefly outlined by the writer, and the sylvicultural work, scouting work and quarantine work, was discussed by Messrs. Clement, Worthly and Rogers.

At the afternoon session a general discussion was taken up in regard to the desirability of more uniform legislation in the different states and suggestions were made relative to changing some features of existing laws so as to bring about better results. Sufficient time was available, so that different men in attendance had an opportunity to discuss features of the work in which they were most interested, and it was the opinion of those present that much benefit and a better understanding of conditions in different parts of the infested territory would result.

During the conference it was brought out that a change in the gipsy moth quarantine regulations was pending and that the Federal Horticultural Board expected to permit the shipment of Christmas trees and Christmas greens in the fall of 1915, after they had been inspected. The present regulations do not permit the shipment of material of this sort outside the areas under quarantine for the gipsy moth. It was the opinion of those present that Christmas trees and greens could not be satisfactorily inspected, owing to the large amount of material which is moved in a short period of time.

On motion of Dr. Hewitt, the thanks of the meeting were extended to Dr. Howard and the writer for calling the meeting and it was voted to hold a similar meeting next winter.

A. F. Burgess.

Juniper Plant Bug (*Chlorochroa uhleri* Stal.) This large, olive green stink bug with pinkish markings is easily recognized and usually rare, though in June, 1894, it was reported from Brockport, N. Y., as having nearly destroyed a crop of peaches. Several years ago we found some eight or ten of these bugs on a small pine tree at North Chatham, and the past summer reports of the unprecedented abundance of this insect, accompanied by serious injury, were received from Mr. M. A. Soule, Quaker Street, Schenectady County, N. Y. Mr. Soule states that the bugs were thick on sunflower seeds, that they injured green corn and destroyed small peas while still within the pods, the insects evidently piercing the pods and drawing the sap direct from the seeds, and in this way preventing a normal development. Tomatoes were also injured and turned black at the point of attack within a few days. Quantities of currants and berries were likewise spoiled.

Mr. Soule kindly forwarded a number of living bugs and we were able to verify the reports so far as corn and tomatoes were concerned. The insects repeatedly established themselves upon the surface of a tomato, and after a time the slender, chitinous lancets were forced into the fruit to their full extent, the ensheathing labium folding back near its middle as the head was pushed down until its lower margin touched the surface of the fruit. One bug remained over a feeding puncture twenty-seven minutes, repeatedly raising and lowering its head as it partly withdrew or forced the lancets into the fruit. When the latter occurred the lancets were supported only by the tip of the labium and the tissues which they pierced. The next day the fruit showed an oval, slightly sunken area about a quarter of an inch in diameter, the center being marked by a minute puncture. This injured spot became more visible the second day, and later exhibited some discoloration. A similar injury was also observed to kernels of sweet corn in the milk.

The Juniper plant bug was by far the most abundant species concerned in this injury, though the related *Euschistus variolarius* Pal. Beauv. was present in much smaller numbers and was observed feeding upon both corn and tomatoes. This latter insect apparently experienced less difficulty in piercing the skin of the tomato, though it did not drive the lancets so deeply into the fruit as to necessitate the folding of the labium.

E. P. Felt.

A Cricket Predaceous on the Termite. While observing a flight of termites (*Termes lucifugus* Rossi) at Manhattan, Kansas, on October 6, 1914, the writer noticed a common field cricket (*Gryllus pennsylvanicus* Burm.) feeding on the termites as they emerged from the ground. The cricket was between two of the holes from which the termites were emerging and was devouring one termite after another. During the fifteen minutes that the cricket was under observation it caught and devoured eleven termites.

J. W. McColloch, *Manhattan, Kansas.*

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

APRIL, 1915

The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published, so far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceding publication. Contributors are requested to supply electrotypes for the larger illustrations so far as possible. Photoengraving, may be obtained by authors at cost. The receipt of all papers will be acknowledged.—Eds.

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The comparative uselessness, so far as many complaints of insect depredations are concerned, is apparent to practical entomologists, because all too frequently the presence of a pest in numbers is not recognized until most of the damage has been done or it is too late to accomplish much in checking the trouble. In some instances preventive measures should be adopted months before the outbreak occurs, and frequently the probabilities are against a recurrence of the trouble in the locality the next season. And, even if the latter were the case, there are many chances against the adoption of timely and effective control measures. These well-known conditions lead us to raise the question as to the responsibility of the practical entomologist. Is there not an obligation upon him to forewarn his clientage of a probable danger and the best methods of meeting the situation? If this be true, and few will dispute it, have economic entomologists discharged their full duty in this respect? We admit that forecasting insect outbreaks has its perils and all statements of this character should be most carefully qualified. It is frequently possible to make positive statements respecting the probabilities of the next season or the next few months, and, while this is often done in the case of a few insects, we are by no means certain that entomologists have lived up to their opportunities systematically. There is a constantly increasing literature on insect outbreaks and their causes, and special studies along this line may well be ranked as among the most practical investigations. This data should be used wherever there is an opportunity and the American public trained to take advantage of the "advance" information available. Control before serious damage has been caused is an infinitely better proposition than destruction of pests after half the crop has been ruined. The value of preventive measures

can hardly be emphasized too strongly. Next to that, we may well dwell upon the preliminary signs of insect outbreaks in an effort to accustom agriculturists to correctly interpret local conditions, especially in relation to unusual depredations. The usual, annual pests are as a rule fairly well controlled. There is relatively greater loss from insects which occasionally become very destructive, largely because someone fails to appreciate the significance of the preliminary signs. The entomologist cannot hope to be in all sections of his territory. He usually can have some type of fairly competent observers in important localities and such parties, if possible, should be well posted along these lines, and promptly report all suspicious developments.

Reviews

The House-Fly, *Musca domestica* Linn., Its Structure, Habits, Development, Relation to Disease and Control, by C. Gordon Hewitt. University Press, Cambridge, 1914, pp. i–xv, 1–382, figs. 104.

This exhaustive and valuable study of one insect is the outcome of investigations continued over a series of years and is "primarily intended for the use of entomologists, medical men, health officers and others similarly engaged or interested in the subject." It is a detailed anatomical, biological and ecological study of an insect, duly correlated with the investigations of others, for the purpose of establishing a substantial basis for practical control work. A portion has been published earlier, but, as pointed out by the author, the advances of recent years have been so great as to necessitate the rewriting of the entire work. Aside from the very full account of the house-fly, other species occurring in houses are briefly noticed and their characters in both larval and adult stages given. The pathogenic phase, a most important subject, is considered in detail and occupies about 100 pages; chapters in this part dealing with the dissemination of pathogenic organisms by flies, the carriage of typhoid fever, the relation of flies to summer diarrhœa of infants, the dissemination of other diseases, etc. The most approved control methods are summarized in chapter 26. The author's personal knowledge of both English and Canadian conditions enables him to discuss the matter from an unusually broad standpoint. The illustrations are excellent, the colored figures being particularly good.

A bibliography of 37 pages indicates the ground which must have been covered in the preparation of this work, not to mention the original studies of the author. Both scientist and layman are indebted to this investigator for placing the information regarding this most dangerous insect in such convincing and convenient form. The volume is indispensable to all desiring detailed information—a prerequisite to the successful control of this pest.

Handbook of Medical Entomology, by Wm. A. Riley and O. A. Johanssen. Comstock Publishing Company, Ithaca, N. Y., 1915, pp. i–x, 1–348, figs. 174.

The developments in medical entomology have been so rapid and the subject is of such vital importance, as to amply justify the preparation of this volume, a work designed to "afford a general survey of the field, and primarily to put the

student of medicine and entomology in touch with the discoveries and theories which underlie some of the most important modern work in preventive medicine.". This volume is written by entomologists possessing a keen appreciation of the applied or medical aspects of the subject, a viewpoint, we believe, essential to the most successful prosecution of investigations along this line.

The first chapter gives a brief historical survey of the early suggestions regarding the transmission of disease by insects. The next contains a somewhat detailed discussion of forms directly poisonous to man, that relating to spiders, ticks and stinging insects being particularly interesting and demonstrating in a convincing manner the errors sometimes characteristic of popular beliefs. About 60 pages are devoted to species parasitic on man, ticks, lice, mosquitoes and fleas—all represented by one or more important disease-carriers, which latter receive special attention.

The dissemination of disease by insects and their allies—the foundation of medical entomology—is discussed in its various phases in chapters 5–11, a total of about 100 pages. The more important disease-carriers are somewhat fully treated in this portion of the work; house-flies, fleas, mosquitoes, tsetse flies, and their relations to diseases indicate a portion of the field covered.

The necessity of identifying noxious forms has been met by tabulations of the characters of dipterous larvæ most likely to be encountered (p. 136), of flies frequently mistaken for house-flies (p. 145) and of hominoxious arthropods, chapter 12. This feature and the extended and well selected bibliography add greatly to the value of the volume, especially for the investigator. There is a large series of excellent illustrations.

The subject is world-wide in application, vital in interest and the authors, by painstaking study and investigation, have produced a work which must be extremely serviceable to an extended cliental.

The Apple Maggot, By W. C. O'Kane, New Hampshire Agricultural Experiment Station, Bulletin 171, pp. 1-120, 1914.

In this large bulletin Professor O'Kane has given us the results of a long and careful study of an important pest. It is evident that no pains have been spared to make the investigation thorough, and in consequence a great deal of valuable new data has been obtained. The bulletin is written in a clear, simple, concise style. It is illustrated by two maps, sixteen photographs, one drawing and several charts of orchards used in the experiments. Most of the photographs are good, but a few are of an inferior character. Considering the comprehensive nature of the work and the value of good figures, one feels that it would have been an improvement if more good illustrations had been added representing the various stages of the insect, either natural size or both natural size and enlarged.

The bulletin begins with a good summary of contents. This is followed by an excellent account of the early history, food plants, distribution and destructiveness of the pest in North America. Then comes a discussion of its economic importance in New Hampshire. The remaining eighty-five pages are devoted to an elaborate account of the life history and habits of the insect, natural enemies, control experiments and recommendations for control. The last four pages contain a good bibliography.

The subject-matter throughout has been well handled and due attention given to each phase, except that it would probably have been better if another paragraph or two had been added giving a more detailed account of the nature of the injury done by the insect and the manner of distinguishing this from the injuries of other apple insects or from the Bitter Pit disease, which is so frequently mistaken by fruitgrowers for it.

Of the many valuable data given, the following are some of the most interesting and important, either as new contributions or confirming the conclusions of earlier investigators.

The flies begin to emerge in New Hampshire some years as early as the last week in June. The maximum emergence is reached the second and third weeks in July and emergence is practically at an end by the middle of August. Egg-laying extends from early July to the latter part of September. Adults may begin to oviposit inside of a week. (It had hitherto been supposed that two weeks or at least ten days was the minimum time between emergence and oviposition.) Efforts were made to determine the average length of time before oviposition but were unsuccessful. This was due to the difficulty of getting adults to act normally in any kind of cage devised. The same difficulty made it impossible to determine either the average or maximum length of life of individuals under normal conditions. There is only one brood a year in New Hampshire. (Illingworth has reported two from New York.) Eggs hatch in from five to seven days. There is a very high mortality of eggs or larvæ or both in all kinds of fruit. This is least in early apples and greatest in winter varieties, in the latter case often reaching to 100 per cent. Larvæ do not leave the fruit, except in rare instances, until after it falls and has become mellow. The maximum issuance of larvæ occurs from infested fruit dropping early in the ripening season. Some of the factors that determine the degree of infestation of one variety compared with another are: early ripening, aroma, and thickness of skin. These factors may act separately or in combination. A small percentage of pupæ do not emerge at the ordinary time but remain two winters in the soil, thus making a two-year cycle. This tends to some extent to complicate control measures. Soil fumigants can scarcely be relied upon as a practicable or effective means of control. Cultivation does not control or have any noteworthy effect on the insects. Pupæ cannot in orchard practice be buried deeply enough to prevent emergence. Firming the soil would seem to be impracticable as a means of control. Poultry are helpful but usually are not available in sufficient numbers. No kind of bait has been discovered that appreciably attracts the adults. Sweetened poisons sprayed on the trees give very little indication that they can be relied upon to control the pest. The one great remedy is the destruction of infested fallen fruit before the larvæ can escape. The fact that the larvæ will not emerge until the fruit is mellow and that the great majority come from early ripening fruit simplifies this means of control. Barnyard stock, especially sheep, hogs and cattle, may be utilized in the destruction of this fruit.

Such are some of the most important conclusions reached in this bulletin. The evidence on which they are based seems in almost every case to be satisfactory. However, on the question of the value of spraying with sweetened poisons there is room for doubt whether this method was given a fair test. It is clear that the author felt satisfied that all the necessary conditions for such a test had been fulfilled. A careful perusal of his experiments will show, however, that in no case was nearly all or even half of an orchard sprayed, but only from one to three trees, and these were, so far as can be learned, never farther than fifty yards distant from unsprayed trees and usually much nearer. The experiments were planned evidently on the assumption that the flies for the most part do not travel much through the orchard before beginning to lay eggs or later. In our work on Cherry Fruit-Flies we at first tried this same manner of testing the sweetened poison with the same belief about the habits of the flies, but soon found that no satisfactory results could be obtained unless we sprayed almost all the orchard. Once this discovery was made we were able to take the worst infested orchards in the province and almost exterminate the pest in them. As the habits of Cherry Fruit-Flies are very similar to those of Apple Maggot Flies, we

are of the opinion that the sweetened poison spray should not be considered a failure against the latter pest until it has been tested under different conditions. The best test, we believe, is to choose two isolated orchards, both badly infested the previous year, and treat them alike in all respects, except that the one shall receive at least three applications of sweetened poison (2 or 3 lbs. arsenate of lead to 50 gals. water, sweetened with 1 gal. of cheap molasses), the first application to be made as in Professor O'Kane's experiments, as soon as the earliest flies appear, and the others at intervals of about 10 or 12 days. Both the upper and under surfaces of the leaves should be covered to prevent the mixture being all washed off by heavy or prolonged rains. If these occur the intervals between the applications may have to be shortened or in some cases an extra application given. For best results no unsprayed trees should be left nearer than about 200 yards from the sprayed trees. Cages should be placed over the ground under the worst infested trees in both orchards to compare the respective number of flies that emerge in each and thus act to some extent as a check. L. C.

Insects of Economic Importance, Outlines of Lectures in Economic Entomology, By GLENN W. HERRICK, pp. 1-138, 1915.

This volume, as indicated by its title, is the outline of lectures given by the author and presents in brief compass the salient facts regarding a large number of the more important insects, together with a discussion of control methods, insecticides and quarantine and insecticide laws. The arrangement is based upon the plant affected, the enemies of all the principal fruit, field and garden crops both north and south receiving due attention. There are also chapters on shade tree insects, the pests of the various domestic animals and those occurring in the house. There is no discussion of forest insects, presumably because this matter is taken care of in the College of Forestry. The treatment is practical, necessarily condensed and with each account of an insect there are given several well selected references to additional sources of information. Professional entomologists will find this a very convenient manual; for the practical farmer or fruit grower there are excellent diagnostic accounts of the injuries caused by the various pests together with directions for their control, while for the student we know of no better guide to the immediately practical side of applied or economic entomology.

Current Notes

Conducted by the Associate Editor

Mr. H. O. Marsh, entomological assistant, Bureau of Entomology, is temporarily stationed at Phoenix, Ariz.

Mr. C. Mason has recently taken up the post of Entomologist to the Department of Agriculture, Nyasaland.

Mr. A. Rutherford, entomologist, Royal Botanic Gardens, Ceylon, died February 3, from heart failure, following enteric fever.

Prof. G. M. Bentley, state entomologist of Tennessee, has been elected secretary-treasurer of the newly organized Tennessee State Florists' Society.

Mr. R. Veitch, late entomological assistant to the Imperial Bureau of Entomology, has taken up the post of entomologist to the Colonial Sugar Refining Company, Ltd., in Fiji.

Mr. Roy E. Campbell, scientific assistant, Bureau of Entomology, formerly stationed at Sacramento, Cal., will remove his headquarters there and establish a new station at Hayward, Alameda County, Cal.

Dr. Frank L. Thomas, a graduate of the Massachusetts Agricultural College, has taken up his new work as field assistant in entomology at the Alabama Agricultural Experiment Station at Auburn, Ala.

According to *Science*, Dr. Charles H. T. Townsend delivered an address on "Verruga and Its Transmission," at the tenth annual banquet of the Tompkins County Medical Society at Ithaca, N. Y., February 16.

Entomological Assistant W. D. Edmonston and Entomological Ranger George Hofer have joined Entomological Ranger Morris Chrisman, Bureau of Entomology, in the investigation of forest insect conditions in the mountains of southern Arizona.

According to *Science*, two French entomologists, M. Reymond Morgon and M. Andre Vuillet, have been killed in battle. The publication of the *Bulletin de Societé Entomologique de France* has been resumed.

All divisions of the Bureau of Entomology, which are located in Washington, are now housed under one roof, as the Bureau of Biological Survey has moved out of the building, which is now devoted entirely to entomology.

Mr. C. F. Stahl, scientific assistant, Bureau of Entomology, has closed his station at Jerome, Idaho, and is opening a new station at Spreckels, Monterey County, Cal., for the study of the curly-top leafhopper (*Eutettix tenella* Baker).

Mr. W. W. Yothers, Bureau of Entomology, has been in Washington for consultation on citrus work in Florida. Mr. Sasscer visited Florida, inspecting Government plant introduction stations and looked after details of the enforcement of plant quarantines.

The work of the Sleeping Sickness Commission of the Royal Society having now terminated, Mr. W. F. Fiske and Dr. G. D. H. Carpenter are continuing their investigations into the bionomics of *Glossina* in Uganda under the direction of the Imperial Bureau of Entomology.

Dr. W. A. Lamborn, late entomologist to the Department of Agriculture, Southern Nigeria, has been appointed travelling entomologist in East Africa, under the Imperial Bureau of Entomology, in place of Mr. S. A. Neave, and is engaged on *Glossina* work in Nyasaland.

Mr. R. S. Leiby, for two and one-half years assistant in insect morphology at Cornell University, is now assistant state entomologist of North Carolina, with headquarters at Raleigh, filling the position made vacant by the resignation of C. L. Metcalf, who is now at the Ohio State University.

During January, Mr. Charles H. Popenoe, entomological assistant, Bureau of Entomology, was engaged at Laredo, Texas, in what is recognized as the principal onion-growing region of the South, in coöperation with Mr. M. M. High, in testing a traction sprayer designed especially for onion fields.

Mr. Fred A. Johnston, entomological assistant, Bureau of Entomology, will close the station representing this branch of the Bureau at Riverhead, Long Island, N. Y., and will establish a new station at Hart, Oceana County, Mich. One of the most important economic projects will be the control of the pea aphis.

Surgeon-General William C. Gorgas was awarded the Louis Livingston Seaman medal for progress and achievement in the promotion of hygiene and the mitigation of occupational disease, at the annual exercises of the American Museum of Safety held in New York on February 10. Congress, before adjournment, promoted him to the rank of major-general in the medical department.

A general conference was held on December 18, at Washington, to consider the danger of the introduction of the pink bollworm in the United States. The consensus of opinion expressed was that the present situation demands a quarantine against all foreign lint, with a provision for the importation of such cotton only in states outside of the cotton belt. It was also proposed that such southern mills as require foreign cottons be allowed to obtain it from stocks which have been in storage in northern localities for at least a year's time.

The Entomological Society of America elected, at the Philadelphia meeting, officers as follows: President, Vernon L. Kellogg, Leland Standford Junior University; first vice-president, J. S. Hine, Ohio State University; second vice-president, J. M. Aldrich, United States Bureau of Entomology; secretary-treasurer, Alex. D. MacGillivray, University of Illinois; temporary secretary for summer meeting, E. C. Van Dyke, University of California; additional members of the Executive Committee, C. T. Brues, Harvard University; W. A. Riley, Cornell University; T. D. A. Cockerell, University of Colorado; J. A. G. Rehn, Philadelphia Academy of Natural Sciences; A. L. Melander, Washington Agricultural College.

The reports on experimentation and demonstration control work against the *Dendroctonus* beetles, carried on in the Yosemite National Park, Bureau of Entomology, in coöperation with the Department of the Interior, with Entomological Ranger J. J. Sullivan as instructor on practical details, and on private lands of the McCloud River Lumber Company, north of Mt. Shasta, in California, with Entomological Ranger J. D. Riggs as instructor, show the following results: In the Yosemite Valley and vicinity, at an elevation of from 4,000 to 7,500 feet, 302 Dendroctonus infested trees were treated, consisting of yellow, Jeffrey, and sugar pine. The trees ranged in di-

ameter, breast high, from 12 to 68 inches, with an average of 31 inches. The average cost of felling, barking, and the necessary burning, was $2.57 per tree. In the Toulumne River and Tenaya Creek, drainage of the Yosemite Park, at an elevation of from 8,000 to 9,500 feet, 2,018 infested lodgepole pine trees, ranging in diameter from 14 to 52 inches, averaging 23.7 inches, were treated at an average cost of $1.13 per tree for felling and burning the bark on the trunks sufficiently to kill the insect. Fifteen hundred and eighty-four infested trees were treated in this general area in 1913. The total number of trees treated in the Valley and Park, during 1913 and 1914, were 3,904, at a total cost for control work of $4,713.43, or an average of $1.21 per tree.

On the 17th and 18th of February the New Jersey Mosquito Extermination Association held its second annual meeting at Atlantic City, N. J. The program was opened by the president's address and a symposium on the special problems which have had to be met in the practical work of mosquito control. Among the points new to mosquito work it was shown that on shut-in, low-lying, sewage-charged salt marshes, the ordinary trenching was impotent to prevent mosquito breeding under unusual combinations of tide, rainfall and cloudy weather. It was brought out that these difficult conditions were to be met by dikes, tide gates and low-head centrifugal pumps.

During the evening session Dr. L. O. Howard described the work of the Bureau of Entomology on the mosquito problems of the lower Mississippi Valley. He gave figures to show the great extent to which malaria reduces the profits of agriculture through affecting the health of the laborers. He described the thorough and interesting fashion in which the study of malaria carriers is being pursued in that region. Dr. Jacob G. Lipman, director of the New Jersey Agricultural Experiment Station, discussed the value of mosquito work in relation to the agricultural and urban development of New Jersey. He showed how successful mosquito extermination could add two hundred million or more to taxable values.

The morning session was opened by an account of the mosquito work in Connecticut, given by Mr. B. H. Waldron. This paper was followed by an account of malaria in New Jersey, in the course of which Dr. A. Clark Hunt showed that the prevalence of malaria is much greater in certain local areas than is usually recognized. Dr. T. J. Headlee showed that, from the beginning of the mosquito extermination work to the year 1912, approximately $200,000 from all sources had been expended, $130,000 of which had been contributed by the state and $70,000 by municipalities and private individuals. He showed that property values within the protected zone had increased by more than five and one-half millions of dollars and that one and one-half millions of people were relieved to a very noticeable extent from mosquito troubles. He showed that, beginning in the year 1912, the county as a mosquito fighting unit had developed to such an extent by 1914 that it was expending approximately $130,000 a year and affording protection from all species of mosquitoes to one and one-fourth millions of people.

Beginning in the evening and extending through the following forenoon addresses were presented from the standpoint of the legislator, the freeholder and the tax-payer, in the course of which it was clearly brought out that the people paying the bills were satisfied with the progress of the work.

The following officers were elected: Dr. Ralph H. Hunt of East Orange, president; Dr. William E. Darnall of Atlantic City, vice-president; Dr. H. H. Brinkerhoff, of Jersey City, second vice-president, and Dr. Thomas J. Headlee of New Brunswick, secretary-treasurer.

Mailed April 26, 1915.